HP 2470A

2470A DATA AMPLIFIER

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD DYMEC DIVISION

HP 2470A

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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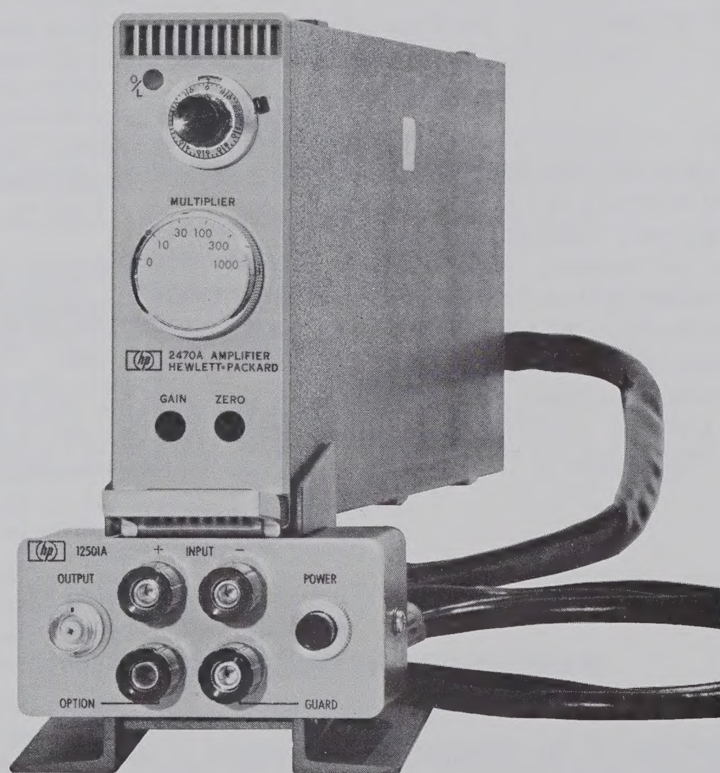
OPERATING AND SERVICE MANUAL

(HP PART NO. 02470-9022)

MODEL 2470A
DATA AMPLIFIER

WITH SERIAL NUMBERS PREFIXED 644-
(Also see information on Page ii.)



HP 2470A-M3, M4 ON HP 12501A BENCH STAND

Printed in U.S.A.

APRIL 1967

IMPORTANT

THIS MANUAL, Stock Number 02470-9022,
APPLIES TO INSTRUMENTS BEARING SERIAL PREFIX 644- **AND**
INCLUDES OPTIONAL MODIFICATIONS:

Within manual: M1, M3, M4, M5

At rear of manual:

INSTRUMENT IDENTIFICATION

SAMPLE SERIAL NO. DECAL

HEWLETT-PACKARD U.S.A.
644-00000

Each instrument is identified by a two-section, 8-digit Serial Number, typed on a decal attached to the rear panel. (See sample at right.) The first 3 digits are a Serial Prefix (type) Number, the last 5 digits identify each individual instrument. ALL INSTRUMENTS WITH THE SAME SERIAL PREFIX ARE THE SAME. Later instruments are covered by a green 'Updating Supplement' at the rear of each manual. Earlier instruments are covered by a blue 'Backdating Supplement', also at the rear of the manual.

SAMPLE 'M' NO. DECAL

HEWLETT-PACKARD U.S.A.
M3 M4 M5

SAMPLE BW DECAL

HEWLETT-PACKARD
2470A - M3,M4,M5
SER: 644-00000
BW: 50 KHZ
M5 BW: 500 HZ
MADE IN U.S.A.

Further information concerning the instrument may be provided by one or two additional decals. One of these, the M number decal (see sample at right), lists the Optional Modifications that are incorporated in the instrument. When used, the M Number decal is attached to the rear panel at the top of the instrument. The second decal is used to specify bandwidths of the main and M5 outputs when the bandwidth of either output is not 50 KHz. When used, the BW decal (see sample at right) is attached to the inside of the case.

MODIFICATION DESCRIPTIONS

Any special Modifications to the equipment described in this manual are explained in "Manual Supplements" added at the rear of this manual.

READ through Section 2 of the basic manual and all accompanying "Manual Supplements" before attempting installation or operation of your equipment, as some special procedures may be necessary.

CONTENTS

CONTENTS (Cont'd)

ILLUSTRATIONS

TABLES

SECTION 1
GENERAL DESCRIPTION

1.1 FUNCTIONAL DESCRIPTION

The Model 2470A Data Amplifier is a wide-band, high-gain differential amplifier for accurate, reliable amplification of low-level signals. Typical signal sources are thermocouples, strain gages, and other resistive transducers with output resistances of 1000 ohms or less. The differential input design of this amplifier offers low drift and 120 db rejection of common mode noise (at gain of 30 or greater) with excellent linearity and long-term gain stability. A self-contained power supply makes this Data Amplifier equally adaptable to bench or data acquisition system use.

The amplifier output will supply ±10v at 100 ma into a resistive or reactive load while presenting a 1000 megohm input impedance to the signal source. The amplifier is self-protected from input overloads up to ±20v dc or peak-to-peak ac (signal + common mode noise) and is not damaged by any output overload, including a short circuit. Also featured by this amplifier, and particularly important for data acquisition systems applications, is its fast settling and overload recovery. An optional overload warning circuit provides a panel lamp indication and an output signal while an overload exists.

1.2 PHYSICAL DESCRIPTION

The 2470A Data Amplifier is fully enclosed and can be adapted for bench operation by a bench stand or a signal and power cable assembly. The bench stand tilts up the amplifier front panel and provides labelled input and output connections for convenient use. Physical measurements are listed in the Specifications. The 2470A is housed in a rugged plastic case that takes more punishment than comparable metal enclosures. Moreover, since the finish is in plastic, it will not show chipping or scratches as painted metal enclosures do. Control titles and settings are lithographed on the plastic. A combining case is available which accommodates up to ten amplifiers. This can be used on the bench or it can be mounted in a 19-inch rack with adapters that are furnished with the case. The case requires only 5-1/4 inches of vertical panel space.

1.3 OPTIONAL MODIFICATIONS

The following standard modifications of the 2470A Data Amplifier are available; their presence is denoted by one or more M-numbers typed on an identification decal attached to the rear panel of the amplifier.

The identification by M numbers is as follows:

M1 Provides four fixed gain steps of x1, x10, x100, x1000, selected at the front panel, instead of the gain steps that are standard. A x0 position shorts the output.

NOTE

On special order, any other fixed gain steps, up to six, between x1 and x1000 may be supplied in place of the x0, x10, x30, x100, x300, and x1000 gain steps of the standard 2470A.

M3 Provides a continuously-variable gain vernier that multiplies the fixed gain by its setting; the maximum multiplication achieved in this way is x3.5.

M4 Provides overload warning indicator and signal.

M5 Provides a second, buffered ±10v, 10 ma full scale output with 2-pole rolloff; bandwidth can be more restricted than main amplifier bandwidth.

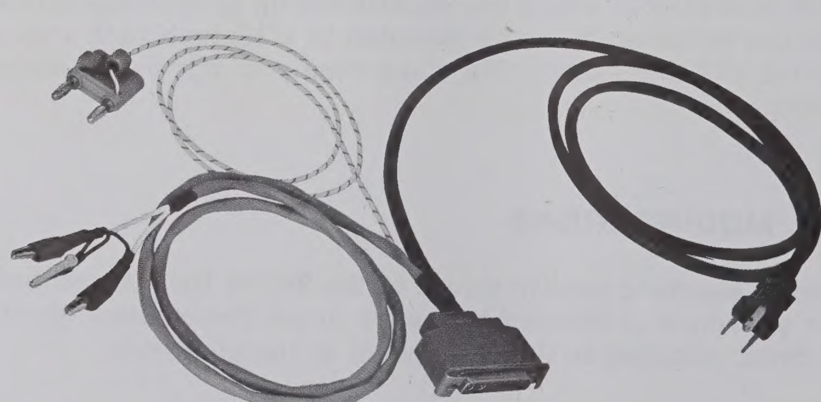
1.4 ACCESSORIES

1.4.1 Mating Rear Connector (12502A)

The mating rear connector is required only if no other means of connecting power and input-output signals to and from the amplifier has been obtained. Parts included are the connector, connector latch, three coaxial inserts, and a protective hood. The accessory number of the mating rear connector is 12502A.

1.4.2 Signal and Power Cable Assembly (12503A)

This assembly (Figure 1.1) consists of a mating rear connector with hood, latch, and with a 3-foot signal input cable terminated by copper alligator clips; a 3-foot signal output cable terminated by a 2-pin banana plug; and a 5-foot power cable terminated by a NEMA plug. The accessory number of this assembly is 12503A.



12503A CABLE ASSEMBLY

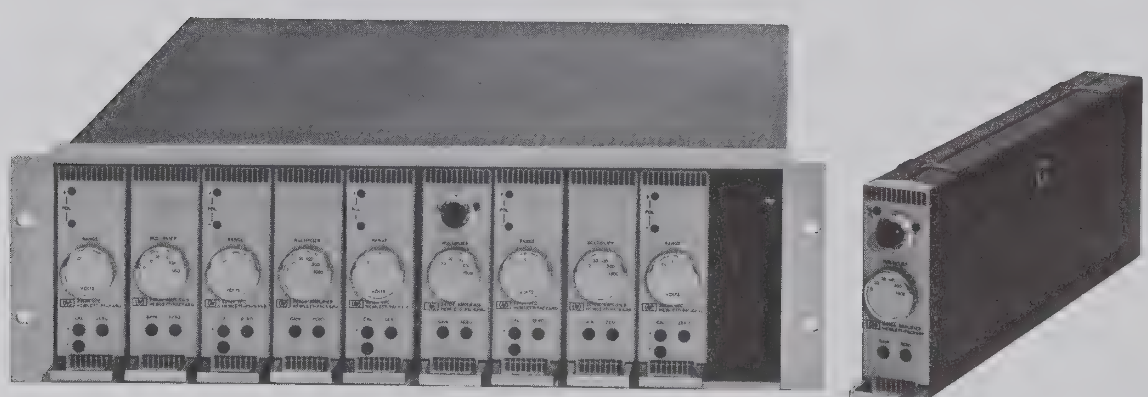
FIGURE 1.1

1.4.3 Bench Stand

The bench stand (Title Page) provides bench support for one amplifier and includes two gold-plated copper signal input binding posts with a guard binding post. It also includes a BNC signal output receptacle, a separate option output binding post, and the mating rear connector wired to the bench stand and to power through a 5-foot power cable terminated by a NEMA plug. A power switch on the bench stand panel has an integral lamp that lights when power is turned on. The accessory number of the bench stand is 12501A.

1.4.4 Combining Case (12500A)

The combining case (Figure 1.2) contains up to ten amplifiers and includes wired mating connectors for all units. The ac power connections are brought out to a single receptacle at the rear of the case and a 7-1/2 foot NEMA-terminated power cable is furnished. System connections to optional overload signal outputs are wired to a rear panel receptacle with capacity for 50 contacts. Sufficient coaxial inserts (30) are supplied to complete input and output signal wiring to the mating receptacles inside the rear of the case. Rack-mount adapters and a fan for cooling the amplifiers are included. A 115/230v switch on the rear panel of the case sets the fan for operation from the 50-60 Hz line voltage being used. The combining case accessory number is 12500A. A blank panel to cover single amplifier space not occupied in this combining case is accessory number 12504A.



12500A COMBINING CASE

FIGURE 1.2

TABLE 1.1 SPECIFICATIONS

Specifications include ±10% line voltage variation, hold for 1K max. source resistance (any unbalance), and assume calibration after specified warmup. (The abbreviations rti and rto mean referred to input and referred to output.)

DC GAIN

Standard: 5 fixed steps of x10, x30, x100, x300, x1000, selected at front panel. A x0 position shorts the output.

Option M1: 4 fixed steps of x1, x10, x100, x1000, selected at front panel. A x0 position shorts the output.

Special: On special order, any fixed steps between x1 and x1000 can be provided, with a maximum of 6 positions.

Vernier (Option M3): 10-turn potentiometer (front panel) extends gain up to x3.5, for any gain setting.

▲ DC GAIN ACCURACY

Calibrated Gain: .01% (resolution of gain trim adjustment). (Factory calibrates gain of 10.)

Other Gains: .03%, consisting of .02% gain-to-gain accuracy and .01% gain trim resolution.

Vernier (Option M3):
Dial Accuracy: ±3%.
Resolution: ±.05%.
Resettability: ±.08%.

GAIN STABILITY

DC: ±.005% per month.

AC: ±.1% per month, for ac to 2 KHz.

Temp. Coeff: ±.001% per °C. (±.002% per °C if optional vernier is used.

LINEARITY

DC: ±.002% of full scale, referred to straight line through zero and full scale output. Applies for all gain settings and inputs of both polarities.

AC: ±.01% of full scale referred to straight line through zero and full scale output. Applies for all gain settings and inputs to 2 KHz.

▲ ZERO DRIFT (OFFSET)

Figures below apply to any gain setting; there is no need to adjust zero on changing gain setting.

Per day: ±5 μv† rti ±50 μv* rto

Per Month: ±25 μv† rti ±250 μv* rto

Temp. Coeff: ±1 μv ±.5 namp rti ±10 μv* rto per °C

† Add 10 μv to rti zero drift figures for operation in free air (without forced air ventilation through the 2470A from rear to front at 1 cfm, minimum).

* Optional vernier (on 2470A-M3) increases rto offset by a factor of up to 2.5.

MAXIMUM INPUT SIGNAL

±11v, differential plus common mode. Combined input up to ±20v will not damage instrument.

DIFFERENTIAL INPUT IMPEDANCE

1000M shunted by .001 μf.

COMMON MODE REJECTION

120 db at 60 Hz, for gain settings of x30 and higher. (60 Hz CMR decreases to 110 db at x10, 90 db at x1.) CMR at dc is 120 db for all gain settings.

▲ COMMON MODE RETURN

From input common to output common: 1 megohm, max. (Provided internally when input lead shields are connected to either side of input).

▲ NOISE

0 to 10 Hz	1 μv p-p rti	and	10 μv p-p rto.
0 to 100 Hz	3 μv p-p rti	and	30 μv p-p rto.
0 to 1 KHz	1 μv rms rti	and	30 μv rms rto.
0 to 10 KHz	3 μv rms rti	and	300 μv rms rto.
0 to 50 KHz	5 μv rms rti	and	500 μv rms rto.

OUTPUT

±10v maximum, 0 to 100 ma. Self-limits at approx. 11.5v, 300 ma.

OUTPUT IMPEDANCE

0.1Ω in series with 10 μh max.

LOAD CAPABILITY

100Ω or .01 μf for full output. Amplifier remains stable and is undamaged by short circuit or capacitive load up to 0.5 μf lumped capacity.

▲ SLEWING

10^6 v/sec rti, 10^7 v/sec rto (inputs of both polarities) with dc offset caused by slew limiting less than .1% of peak ac, provided full scale input is not exceeded.

This assures full scale output over the entire bandpass, except with 2470A-M1 at gain of 1, which slew limits above 16 KHz.

BANDWIDTH

(For any gain step.*)
0 to 50 KHz ±3db
0 to 15 KHz ±1db
0 to 5 KHz ±1%
0 to 1.5 KHz ±.1%
0 to 500 Hz ±.01%

(*With optional vernier, 3 db bandwidth is 20KHz at x3.5 gain setting.)

Note: Other fixed 3 db bandwidths between 100 Hz and 50 KHz available on special order.

SETTLING TIME

100 μs to within .01% of final value.

OVERLOAD RECOVERY

Settling time plus 100 μs for signal of 10 times full scale, but less than 10v. Less than 5 ms for signal plus common mode up to 20v.

TABLE 1.1 (Cont'd)

OVERLOAD SIGNAL

(With Option M4.)
-(17.5 to 19.5)v with no overload, 0 to -1v in overload. 5 ma drive capability. Front panel lamp indication.

DUAL OUTPUT

Second, buffered output, with same level and phase as standard output, available as Option M5.

DC Gain: x1 (referred to main output)

DC Gain Accuracy: ±.01%.

DC Gain Stability: ±.02% per month. (Temp. coeff. ±.005% per °C.)

DC Linearity: ±.02% of full scale.

Zero Drift: ±.005% of full scale rto per day. (Temp.coeff. ±.001% of full scale per °C, rto.)

Output: ±10v maximum, 0 to 10 ma. Self-limits at approx. 11.5v, 35 ma.

Output Impedance: 0.5Ω in series with 10 μh max.

Load Capability: 1K or .001 μf for full output. Amplifier remains stable and is undamaged by short circuit or any capacitive load, and main output is affected less than ±.005%.

Slewing: Full output available at specified 3 db bandwidth (3×10^6 volts/sec max. at 50 KHz).

Bandwidth: Any fixed 3 db bandwidth between 10 Hz and 50 KHz, specified by customer. Must be less than or equal to 3 db bandwidth of main output. 12 db/octave slope.

Settling Time: Determined by bandwidth specified.

Overload Recovery: Cannot be overloaded by main output. Recovers from a short on its output in 2x settling time.

REAR CONNECTOR

All signal input/output and power connections at rear connector. Mating connector listed under Accessories Available. Accessory Combining Case includes mating connectors.

Pin Connections:

1	Output common
2	Overload (with Option M4)
3,5,8,10	Chassis ground
4	AC line (fused)
6	Buffered output common (Option M5)
7	Buffered output (Option M5)
9	AC line (return)
A1	Output (shield is output common)
A2	Input (non-inverted terminal)*
A3	Input (inverted terminal)*

*A2 and A3 shields are guard

ENVIRONMENTAL CONDITIONS

Operating: Ambient temperatures from 0 to 55°C. Relative humidity up to 95% at 40°C. When used individually, instruments are self-cooled by convection. Accessory Combining Case includes fan for additional cooling.

Storage: -40 to +75°C.

▲WARMUP

Instrument operates immediately after turn-on, but requires 1-1/2 hours in free air, 30 minutes in Combining Case (plus 1 hour additional warmup for each 10°C difference between storage temperature and operating ambient) for specified accuracy and zero drift.

RELIABILITY

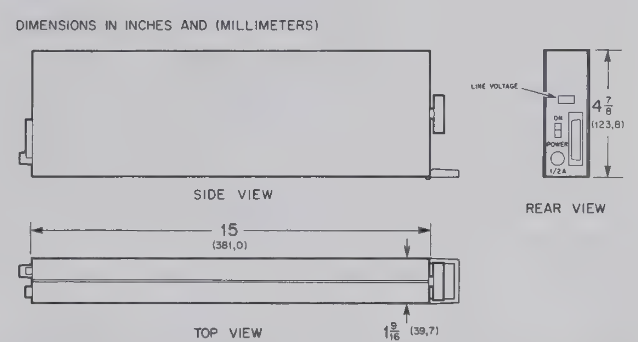
Predicted mean time between failures (with 90% confidence) is 20,000 hours – over two years of continuous operation – when operated at 25°C ambient.

POWER REQUIRED

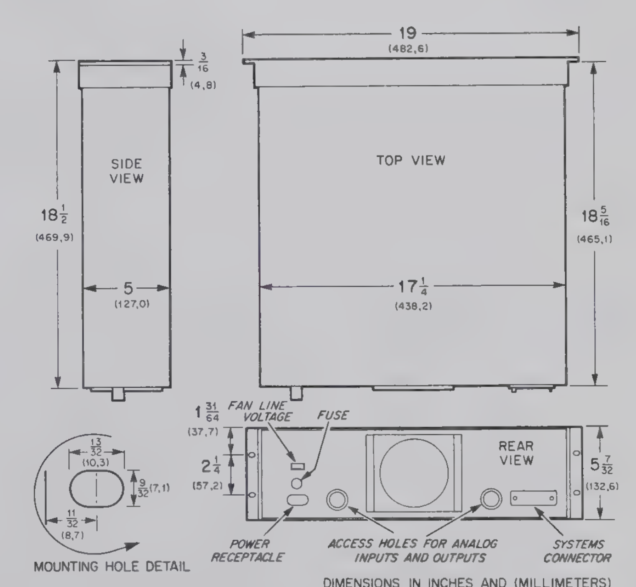
115/230v ±10%, 50 to 400 Hz, 8w with no load, 10w at full load. Fuse, 115/230v and on/off switches on rear panel. Fan in combining case operates from 50 to 60 Hz only.

DIMENSIONS

HP-2470A:



COMBINING CASE:



WEIGHT

Net wt. 4 lb. (1,8 kg); shipping wt. 6-1/2 lb. (2,9 kg).

Combining Case

Net wt. 12-1/2 lb. (5,7 kg); shipping wt. 27 lb. (12,3 kg).

FINISH

Light grey panel; blue-grey texture-finish case.

TABLE 1.1 (Cont'd)

OPTIONAL MODIFICATIONS

(Order by M-number.)

M1. x1, x10, x100, x1000 Gain Steps (includes x0 shorting position).

M3. Gain Vernier: Provides continuously-adjustable gain extension up to x3.5, for any gain setting.

M4. Overload Indication: Front panel lamp indication and output signal.

M5. Dual Output: Second, buffered output added.

Special Gain Steps: Up to 6 fixed steps from x1 to x1000 (can include x0 shorting position). May be combined with Option M3.

ACCESSORIES AVAILABLE

(Order by accessory or stock number.)

1. Mating Rear Connector (not required if Combining Case is used): Accessory No. 12502A
2. Signal and Power Cable Assembly: Consists of mating rear connector with 3-foot signal input cable (terminated with alligator clips); 3-foot signal output cable (terminated with 2-pin banana plug); and 5-foot power cable (terminated with NEMA connector). Accessory No. 12503A
3. Bench Stand: Provides bench support for one amplifier; signal input connectors (two GR plus GR for guard); signal output connectors (BNC, plus GR for overload output); and power cable (5 feet, terminated with NEMA connector). Includes power switch with integral lamp. Accessory No. 12501A
4. Combining Case: Contains up to 10 amplifiers. Includes mating rear connector for each amplifier. AC power connections brought out to single receptacle at rear of case; 7-1/2 foot NEMA-terminated power cable furnished. Access holes provided for signal cables. System connector is MRAC-50S that carries overload output. Mating MRAC-50P plug (5060-2464) is not supplied Equipped with mounting flanges for 19-inch rack. Fan (115/230v) included. Accessory No. 12500A
5. Blank Filler Panel: For use with Combining Case; covers space not occupied by one amplifier to assure correct ventilation of instruments. Accessory No. 12504A

SECTION 2
INSTALLATION AND OPERATION

2.1 INSTALLATION

The 2470A Data Amplifier is a fully-enclosed, self-contained instrument. It requires only suitable connection of signal inputs and outputs and ac power to its rear panel connector for operation. Controls, indicators, and the connector of the various versions of the 2470A are illustrated and described in Figure 2.10 (unfold page 2-17). The user may select any of four connection arrangements. The 12501A Bench Stand and the 12503A Signal and Power Cable Assembly are intended for use with the 2470A operated as a bench instrument. The 12500A Combining Case houses and connects ac power and signal inputs and outputs to as many as ten 2470A amplifiers used in multichannel data system applications. The 12502A Mating Plug is available for users wishing to complete their own wiring arrangements.

2.1.1 Cooling

For best rti zero stability ($< 5\ \mu v$ rti drift in 8 hours) operate the 2470A in the Combining Case (which provides at least 1 cfm forced air ventilation through all instruments in the case – from rear to front). A single 2470A can also be operated in free air (without the ventilation specified above), but rti zero can drift as much as 15 μv in 8 hours, even after 1-1/2 hour warmup. Warmup time in the Combining Case is only 30 minutes.

2.1.2 Fuse

The power line fuse of the 2470A is located beneath a knurled cap (1, Figure 2.10), immediately below the POWER switch (4, Figure 2.10). The replacement for this plug-in fuse is a BUSS GMW 1/2, HP Stock Number 2210-0046.

2.1.3 Operation from 115 or 230 Volts

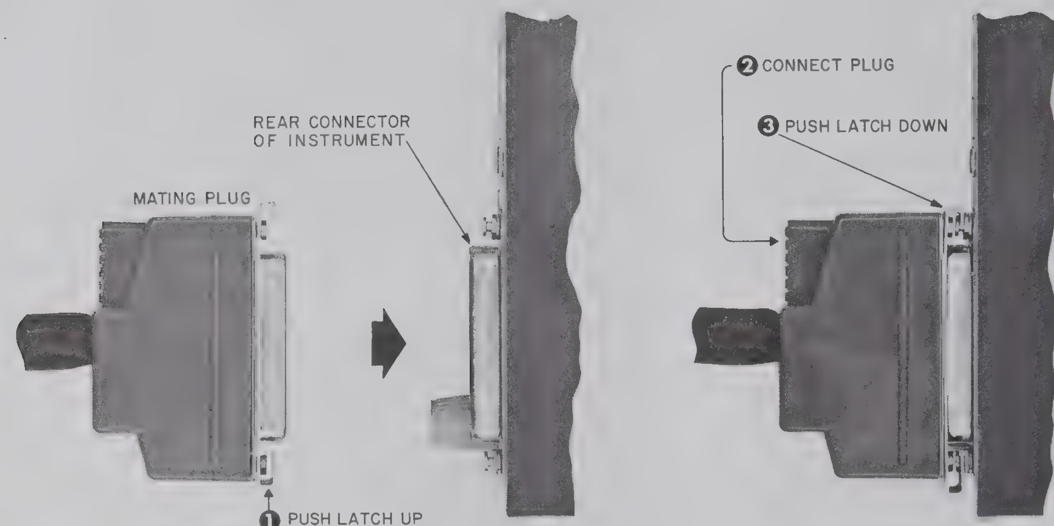
The LINE VOLTAGE switch (2, Figure 2.10) on the rear of the 2470A allows the instrument to be set for operation from either 115 or 230-volt power, at 50 to 400 Hz. The 2470A is normally supplied from the factory with the LINE VOLTAGE switch set to the 115 position.

CAUTION

Before connecting power to the 2470A, make certain that the LINE VOLTAGE switch is set correctly. Slide this switch to the left for operation from 115v, or to the right to operate the 2470A from 230v.

2.1.4 Installation on Bench Stand

Connect the mating plug of the bench stand to the 2470A rear panel connector (3, Figure 2. 10) and lock it in place as shown in Figure 2. 1. Place the 2470A between the bench stand side supports. Set the rear panel POWER switch (4, Figure 2. 10) to ON to permit power on/off control by the Bench Stand POWER switch. Power and signal connections are covered in sections 2. 2 through 2. 2. 8.



CONNECTION OF MATING PLUG TO 2470A

FIGURE 2.1

2.1.5 Installation with Cable Assembly

Connect the mating plug of the Signal and Power Cable Assembly to the 2470A rear panel receptacle and lock it in place as shown in Figure 2. 1. Power and signal connections are completed per sections 2. 2 through 2. 2. 8.

2.1.6 Installation in Combining Case

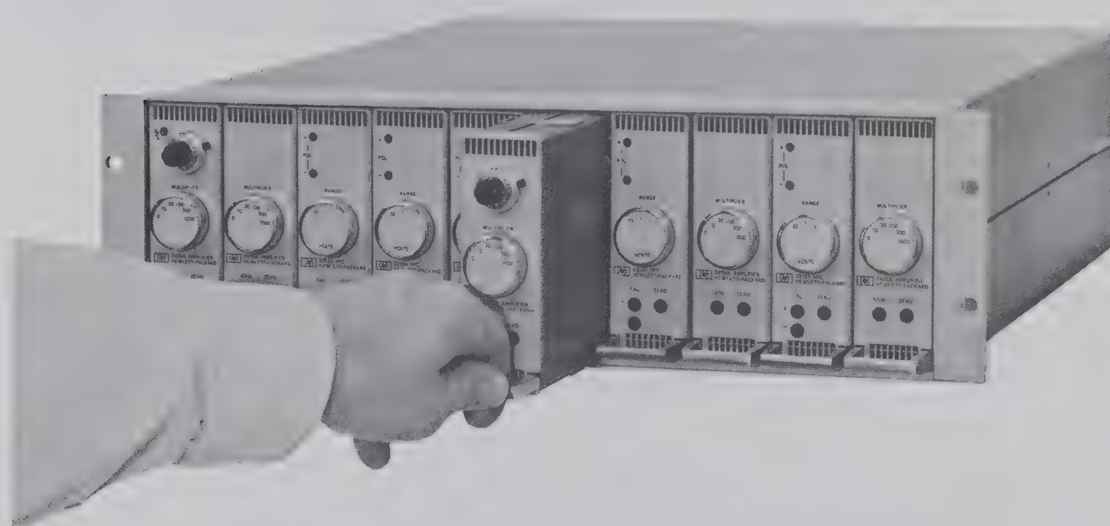
After signal input and output wiring has been completed per instructions in sections 2. 1. 7 through 2. 1. 10, installation of 2470A amplifiers is simple. Set the 2470A rear panel POWER switch (4, Figure 2. 10) to ON and insert the 2470A into the desired position in the case as shown in Figure 2. 2. Make certain the 2470A rear panel connector mates properly with the correct connector in the rear of the Combining Case and push the 2470A into the case until its front panel detent locks into the slot in the front of the Combining Case. To assure correct ventilation of all instruments in the case, install 12504A Blank Panels to cover any vacant spaces.

NOTE A

The line voltage switch on the rear of the Combining Case sets only the line voltage to the fan. LINE VOLTAGE switches on the instruments inside the case must be set individually to the correct voltage.

NOTE B

Although the 2470A will operate from power at line frequencies of 50 to 400 Hz, the fan in the Combining Case operates only from 50 to 60 Hz ac. A special fan must be provided in the Combining Case for operation from other line frequencies, such as 400 Hz. Line frequency must be specified when the Combining Case is ordered.



INSTALLATION IN COMBINING CASE

FIGURE 2.2

2.1.7 Completion of Combining Case Wiring

The 12500A Combining Case is supplied with all but the signal input and output connections fully wired. Completion of wiring thus consists of connecting the signal input and output leads to the 30 coaxial inserts provided for this purpose and installing these inserts into the correct connector mounting holes. Proceed as follows:

1. Pull out on the two plastic quick-release fasteners to remove the rear panel, exposing the instrument mating receptacles as shown in Figure 2. 3.

INSIDE REAR OF COMBINING CASE

FIGURE 2.3

2. Connect the signal input and output cables to the coaxial inserts per sections 2.1.8 through 2.1.10.
3. Bring the signal leads through the cable access holes in the rear panel as indicated in Figure 2.3.
4. At each instrument mating receptacle install the coaxial inserts by pushing them into the correct holes until they snap into place. The lowest hole is for -input insert A3, the middle hole is for +input insert A2, and the upper hole is for output insert A1.

2.1.8 Recommended Signal Cabling

Although 22 gauge shielded hookup wire can be used for connections terminated by the coaxial inserts, teflon-insulated wire is recommended for the following two reasons:

1. Teflon insulation is not subject to the melting experienced when soldering wires insulated with other materials.
2. Teflon insulation preserves the extremely high input impedance of the 2470A, even at high humidity.

Teflon-insulated cabling of the recommended type is available from:

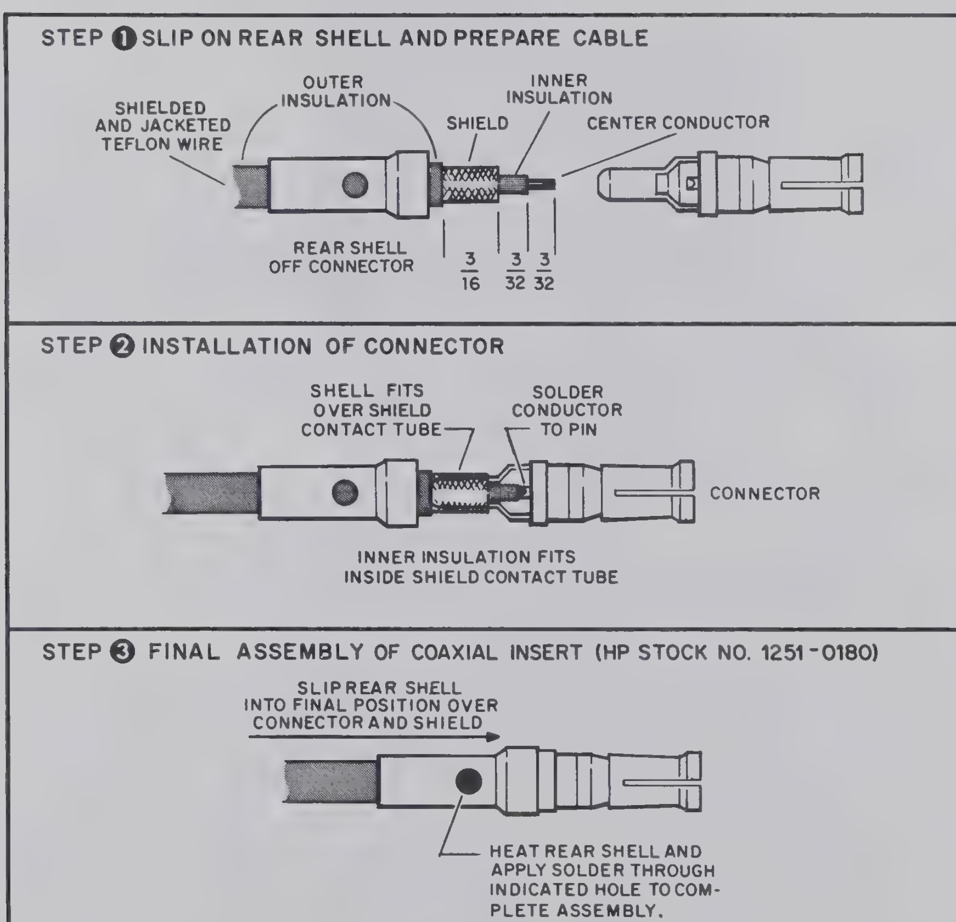
American Super Temp Wires Division of Haveg Industries Los Angeles, California Order cable type T-22-1934-STJ	or:	Tensolite Insulated Wire Co., Inc. Tarrytown, New York Order cable type 1934TX10C1SW

2.1.9 Connection to Coaxial Inserts (see Figure 2.4)

1. Slip the rear shell of the connector over the cable. Strip 3/8 inch of outer insulation from the tip of the cable, carefully to avoid breaking shield braid. Then trim exposed shield back to 3/16 inch length and strip off 3/32 inch of the inner insulation to expose the inner conductor.

2. Slip the connector over the inner insulation and under the shield, fitting the inner wire into the connector pin. Use a fully-heated soldering iron with a very small tip and 60-40 rosin core solder to solder the inner wire to the pin. Wipe the solder joint clean with a small camel's hair brush moistened in Dupont Freon T-E35, or equivalent solvent. Then dry the brush and use it to remove excess solvent.

3. Slip the rear shell of the connector over the shield and the connector. Then heat and solder the rear shell to shield and connector by applying solder through the hole indicated in Figure 2.4.



CONNECTION TO COAXIAL INSERTS

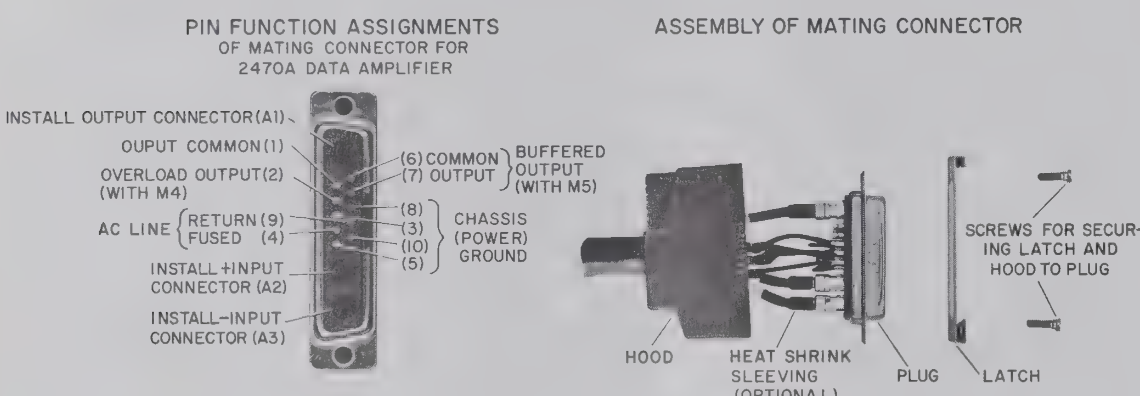
FIGURE 2.4

2.1.10 Insertion and Removal of Coaxial Inserts

The coaxial inserts snap into individual connector mounting holes when pressed in from the rear. Coaxial inserts installed in the wrong position may be removed with a Cannon Electric connector extraction tool, model CET-C6-B, or equivalent. From the front of the connector, slip the outer sleeve of the tool around the insert. Press in to release the insert, permitting its removal. Experimentation may be required to get some inserts to release.

2.1.11 Wiring and Assembly of Mating Plug

The Mating Plug for the 2470A rear panel connector, accessory number 12502A, is supplied with a hood, latch, and three coaxial inserts. Except for signal input and output connections, covered in paragraphs 2. 1. 8 through 2. 1. 10, wiring of the mating plug is simple and straightforward. Pin-function assignments and assembly of the mating plug are shown in Figure 2. 5.



WIRING AND ASSEMBLY OF MATING PLUG

FIGURE 2.5

2.2 CONNECTIONS

2.2.1 Power Ground Connection

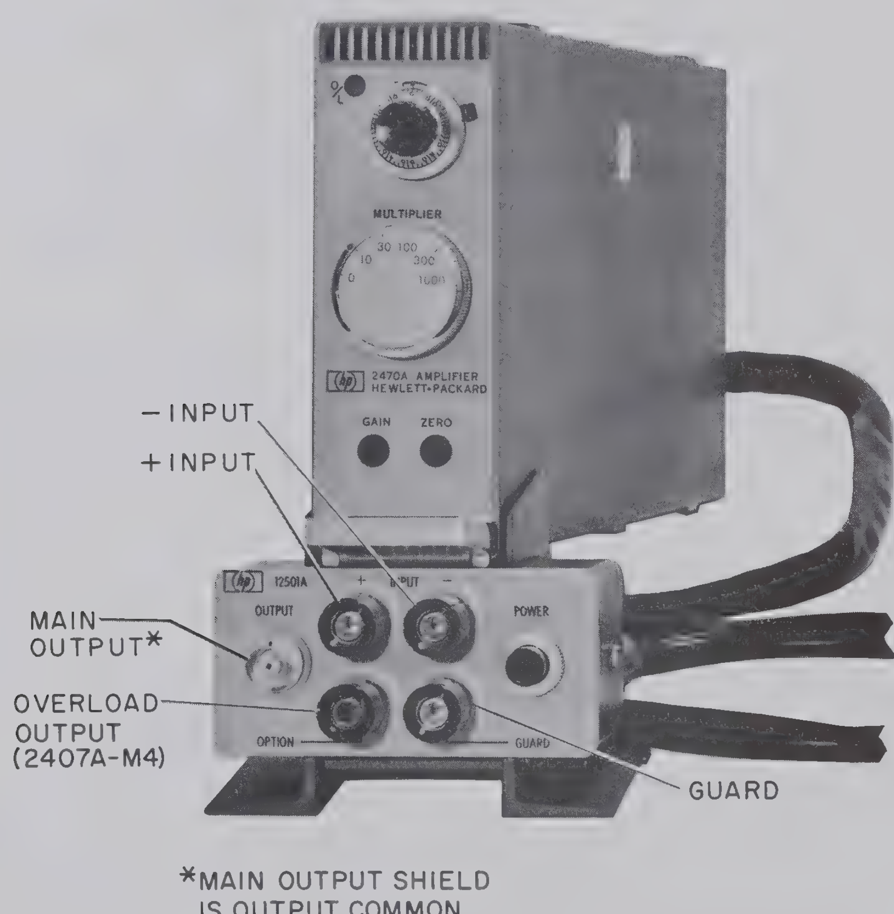
The 2470A contains an internal shield that serves as a chassis ground. This shield must be connected to power ground through any one of rear panel connector pins 3, 5, 8 and 10 to minimize noise susceptibility and radiation. When the bench stand, the signal and power cable assembly, or the combining case power cable is used for connecting power to the 2470A, connect the power plug to a three-wire (grounded) power outlet. When only a two-blade outlet is available, use a connector adapter (HP Stock Number 1251-0048) and connect the short wire from the side of the adapter to ground.

2.2.2 Signal Connections

Connect the 2470A amplifier input and output in accordance with the information in the following paragraphs to achieve most satisfactory operation. Signal connectors of the bench stand are shown in Figure 2.6. Figure 2.7 indicates signal connectors of the signal and power cable assembly. Figure 2.8 shows connections to various types of signal sources.

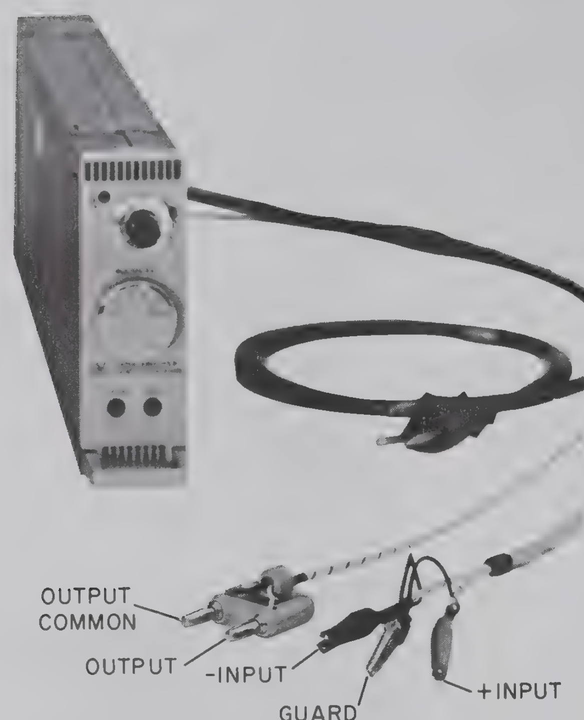
2.2.3 Output Grounding

Output common of the 2470A should normally be grounded at the load, to prevent noise pickup by the load. EXCEPTION: If the load is ungrounded, but well shielded, the load shield may be returned to output common at the 2470A and grounded there. This reduces ground currents in the output common lead.



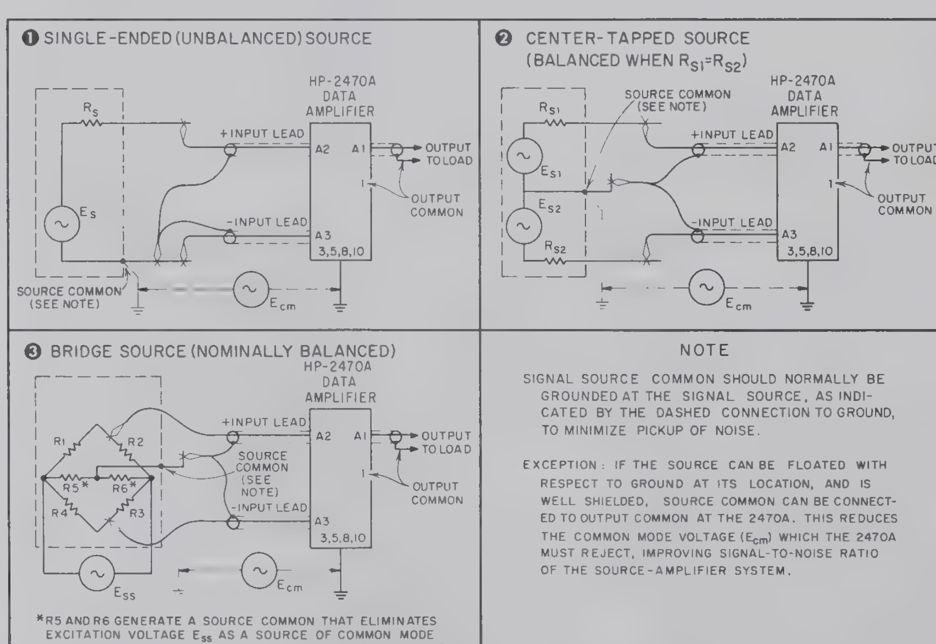
BENCH STAND SIGNAL CONNECTIONS

FIGURE 2.6



CABLE ASSEMBLY SIGNAL CONNECTIONS

FIGURE 2.7



CONNECTIONS TO VARIOUS SIGNAL SOURCES

FIGURE 2.8

2.2.4 Input Grounding and CMV Rating

The 2470A is a four-terminal data amplifier whose input may be grounded at a remote point. However, any potential between the input and output grounds must not exceed the common mode voltage (cmv) rating of the 2470A. For normal operation, the cmv plus signal must not exceed ±11v dc or peak ac, but the instrument will tolerate peak cmv plus signal of ±20v without damage. The common mode return resistance between source common and output common should not exceed 1 megohm.

2.2.5 Guarding

The signal source and input lead A2 and A3 shields are called 'guard', and must be connected to the signal source common through a relatively low impedance (certainly less than 10K). Deterioration of common mode rejection, unnecessary noise, and spurious signals in the output are likely to result from neglect of guarding requirements.

2.2.6 Grounding of Signal Source

The signal source common should normally be grounded at the source to minimize noise pickup. EXCEPTION: if the source is not grounded, but is well shielded, source common may be returned to output common at pin 1 of the 2470A rear panel connector. This reduces the common mode voltage which the amplifier must reject, and consequently improves signal-to-noise ratio of the source-amplifier system.

When the source must be left floating with respect to ground, the return normally provided through earth or power ground may be provided by connecting the guard shields to either input lead. This provides a dc return with resistance of approximately 1 megohm, through resistors installed in the 2470A.

2.2.7 Connection Hardware

Only copper wire, lugs, banana plugs, or alligator clips, preferably gold or silver plated, should be used for input connections to the 2470A. Dissimilar metals used for input connection can act as a thermocouple, introducing significant errors caused by thermally-generated voltages. For example, steel alligator clips used with copper wire can produce a thermal emf as high as 40 microvolts per °C. At any gain, but particularly at gains of 100 or more, this can introduce serious and entirely unnecessary offset errors.

2.2.8 Derating for Differential Source Resistance Greater Than 1000 Ohms

Although the 2470A is designed to work with signal sources having resistance of 1000 ohms or less, it also amplifies signals from sources with resistance greater than 1000 ohms. However, the following effects derate performance.

1. Zero drift and noise increase about equally. The increased rti zero drift voltage can be determined by multiplying the source resistance by 0.5 namp (the rti offset current). Increased zero drift is particularly troublesome at gains of 100, 300 and 1000.
2. Common mode rejection decreases about 6 db for each doubling of unbalanced source resistance.

2.3 OUTPUT

The 2470A Data Amplifier amplifies signals from dc to 50 kHz (±10%), the -3 db point, and supplies up to full ±10v, 100 milliampere output across its entire passband into a resistive or reactive load. The 2470A will drive any length of shielded cable without instability. Its output is self-limiting at approximately ±11.5v and 300 milliamperes, and is not damaged by any passive overload (including a short circuit).

CAUTION

Although the 2470A is not damaged by passive overloads, external sources of ac or dc voltage should never be connected across the 2470A output.

2.4 PREOPERATIONAL CALIBRATION

2.4.1 Equipment Required

1. An HP-721A power supply or equivalent source of ±10 volts.
2. An Electro Scientific Industries RV 722A, 100K Precision Dekavider.
3. An HP-419A null voltmeter, or equivalent.
4. An HP-12500A Combining Case, 12503A Cable Assembly, or 12501A Bench Stand, and suitably terminated test leads as required.

NOTE A

The 2470A meets its stability specifications best when operated in the HP-12500A Combining Case after 30-minute warmup and pre-operational calibration.

NOTE B

Warmup and pre-operational calibration of a 2470A operated in free air should be accomplished with the amplifier in the attitude (upright or on its side) in which it will be used. Changing the amplifier's attitude changes internal temperature gradients, affecting calibration.

2.4.2 Turn-On and Warmup

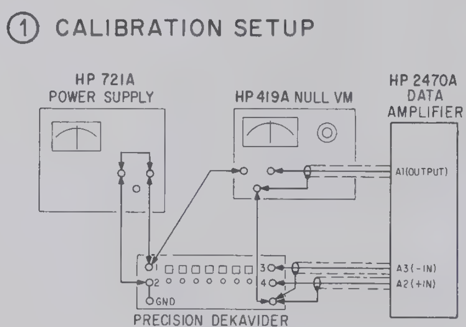
Turn on all equipment and the 2470A. Plug the Combining Case, Cable Assembly, or Bench Stand into a 'hot' outlet (and actuate the Bench Stand POWER switch-indicator). Allow 30 minute warmup in the Combining Case or at least 1-1/2 hour warmup in free air.

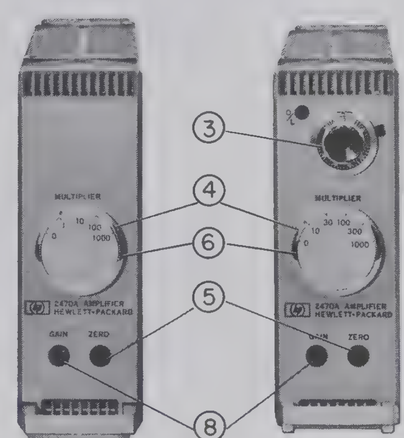
NOTE

If the 2470A has been stored at a temperature other than operating ambient, allow one hour additional warmup for each 10 °C difference between storage and ambient operating temperatures.

2.4.3 Procedure

The procedure for zeroing and calibrating the 2470A Data Amplifier is given in Figure 2. 9.





2470A-M1 2470A-M3,M4

1 With Power Supply off, connect setup shown above, including the shorting plug between the Power Supply '+' and '-' terminals. Turn on the 2470A and the Null VM.

2 Set Dekavider to 0000000 and zero the Null VM and set it to 10 mv range.

3 Set Vernier of 2470A-M3 fully counterclockwise and lock it there.

4 Set 2470A MULTIPLIER to 1000.

5 After specified warmup per section 2. 4. 2, with the 2470A positioned as it will be operated, set 2470A ZERO for minimum reading (less than ±2 mv) on the Null VM. (This is less than ±2 μv referred to the input.)

NOTE: Set 2470A ZERO only at gain of 1000. Zeroing at other gains is an internal adjustment not requiring daily attention; that adjustment is specified in section 4 (maintenance)

6 Select 2470A MULTIPLIER and Dekavider setting from those listed below according to the gain that is to be calibrated.

2470A MULTIPLIER (Gain) Setting	Dekavider Setting
1 (M1 only)	999999TEN
10	1000000
30	0333333
100	0100000
300	0033333
1000	0010000

7 Note polarity and magnitude of zero reading on the Null VM.

8 Disconnect the shorting plug from the Power Supply Set the Power Supply for 10v output. With screwdriver, set 2470A GAIN adjustment for reading within less than 1 mv of that noted in step 7.

ZEROING AND CALIBRATION OF 2470A DATA AMPLIFIER

FIGURE 2.9

2.5 OPERATION

2.5.1 Zeroing Equipment Driven by Amplifier

The '0' position of the MULTIPLIER switch short-circuits the output, to permit zeroing of the device driven by the amplifier without changing system connections.

2.5.2 Basic Operation (See Figures 2.8 and 2.10)

1. Set LINE VOLTAGE switch (2, Figure 2.10) to show the line voltage (115 or 230v) from which the 2470A is to be operated.

2. Install the 2470A per section 2.1.4, 2.1.5, or 2.1.6.

3. Connect the 2470A to external power per section 2.2.1.

4. Calibrate the 2470A for operation per sections 2.4.1 through 2.4.3 and Figure 2.9.

5. Connect the 2470A input and output as indicated in the appropriate diagram of Figure 2.8. Observe the specific instructions in sections 2.2.2 through 2.2.8.

6. Set the MULTIPLIER switch (5, Figure 2.10) according to the input voltage, as follows:

Input Voltage	MULTIPLIER
to 10 millivolts	1000
to 33 millivolts	300
to 100 millivolts	100
to 333 millivolts	30
to 1 volt	10
to 10 volts	1*

*With Option M1

NOTE

Zero and calibration stability of instruments operated in the Combining Case depends upon correct ventilation. To assure that all instruments receive adequate ventilation, the air filter at the rear of the Combining Case should be cleaned every 30 days (more frequently if operated more than 80 hours per month or where airborne vapors and dust may cause rapid clogging). For cleaning directions, see page 6 of the instruction booklet provided with your Combining Case.

2.5.3 Using the Optional Vernier

The vernier (8, Figure 2.10) on the 2470A with Option M3 permits multiplication of the fixed setting of the MULTIPLIER switch by any factor from 1 to 3.5. When the 2470A is equipped with M3, any gain from 10 to 3500 may be set. However bandwidth decreases with gain down to 20 kHz with full vernier multiplication.

The turns-counting dial of the vernier provides a three-digit indication that can be used to determine the gain, or to set a specific gain. Since the vernier adds a 2.5X maximum multiplication factor to the basic gain, each turn of this ten-turn control adds a 0.25X multiplication factor Gain multiplication (Gm) of the fixed range setting by the vernier is given by the following expression:

$$Gm = 1 + 0.25\,Vs$$

Where Vs is the number of turns indicated by the turns-counting dial of the vernier.

At dial settings of 8.00 or 3.54:

$$Gm = 1 + (0.25 \times 8.00) = 3$$
$$Gm = 1 + (0.25 \times 3.54) = 1.885$$

The dial setting (Vs) for a specific gain multiplier (Gm) is given by the following expression:

$$Vs = \frac{Gm - 1}{0.25}$$

For Gm of 1.5 or 2.5:

$$Vs = \frac{1.5 - 1}{0.25} = 2.00 \text{ (2 turns)}$$

$$Vs = \frac{2.5 - 1}{0.25} = 6.00 \text{ (6 turns)}$$

2.5.4 Use of the Overload Signal Option

The O/L indicator (9, Figure 2.10) on the 2470A-M4 Data Amplifier lights when the differential input signal tries to drive the output voltage beyond approximately ±11.5 volts. Accompanying this visual indication is an electrical signal (about -18 volts with no overload, 0 to -1 volt in overload) provided from pin 2 of the rear panel plug, with respect to output common (pin 1). The overload signal can be used to trigger an alarm or a remote indicator.

Aside from protection of the amplifier if the input voltage exceeds full scale, the most valuable advantage of the overload signal option is speedy detection of transducer failures. Open-circuiting of a bridge usually applies excessive input voltage to the amplifier, which is immediately detected and signalled by the overload circuit. Then the defective transducer can be located and replaced before its failure has caused extensive loss of data.

2.5.5 Use of the Buffered Output Option

The buffered output, supplied as optional modification M5, permits a second output load to be driven by the amplifier, in isolation from the main output. The buffered output supplies up to ±10 volts at ±10 milliamperes maximum to a load connected between pins 7 (output) and 6 (common) of the rear panel connector. Like the main output, the buffered output may be overloaded (even short-circuited) without damage. Moreover, short-circuiting the buffered output affects the main output less than ±0.005%. If requested, the buffered output is provided with a narrower bandwidth than the main output. Detailed specifications of the second output are presented on page 1-5.

2.6 OVERALL ACCURACY

2.6.1 Accuracy Factors

Overall accuracy of the 2470A Data Amplifier output is determined by the following factors:

1. Zero drift (offset): ±5 μv rti ±50 μv rto for 8 hours when operated in the Combining Case or ±15 μv rti, max, ±50 μv rto for 8 hours when operated in free air (without forced air ventilation through the 2470A from rear to front at 1 cfm, minimum).
   ±1 μv ±0.5 namp rti ±10 μv rto per °C change of ambient temperature.
2. Linearity: ±0.002% of full scale.
3. GAIN adjustment resolution: 0.01% of reading.
4. Gain-to-gain accuracy: ±0.02% of reading.
5. Gain stability: ±0.005% of reading per month ±0.001% of reading per °C.

2.6.2 Calculation of Zero Drift

Zero drift is a percent of full scale error whose magnitude at the output is determined by gain, time, and temperature shift after zeroing. Source resistance enters into the temperature coefficient portion of the calculation. To determine the magnitude of zero drift error (Ezd) as a percentage of full scale, use the following formula (assumes operation in Combining Case).

$$\text{Ezd (\% fs)} = \frac{\pm 5\ \mu\text{v} \times \text{gain} \pm 50\ \mu\text{v}}{0.01 \times \text{full scale output in } \mu\text{v}}$$

$$\text{Ezd (\% fs)} = \frac{(\pm 0.5\ \text{namp} \times \text{Rs} \pm 1\ \mu\text{v}) \times \text{gain} \pm 10\ \mu\text{v per }^\circ\text{C}}{0.01 \times \text{full scale output in } \mu\text{v}}$$

Assuming 500 ohms source resistance (Rs), gain of 100, and no temperature change after zeroing, total Ezd will not exceed the following percent of full scale error for 8 hours:

$$\text{Ezd \% fs)} = \frac{\pm 5 \times 100 \pm 50}{10} = \pm 0.0055\%\ \text{fs}$$

Under the stated conditions, temperature shift after zeroing would add a further Ezd percent of full scale error of no more than ±0.00135% per °C.

2.6.3 Summing Errors to Determine Accuracy

Once zero drift error (Ezd) is known for the operating conditions as a percentage of full scale, overall accuracy can be determined. For instance, total errors at gains of 10, 30, 100, 300, and 1000, assuming operation in the Combining Case and no temperature change after zeroing, are summarized in Table 2. 1. Additional errors caused by temperature change after calibration are listed in Table 2. 2 for 500 ohm source unbalance and the same ranges.

TABLE 2.1

8-HOUR ACCURACY OF 2470A DATA AMPLIFIER
(assuming operation in Combining Case, constant temp.)

Error Factors	% of Full Scale Errors					% of Reading Errors	
	Gain = 10	Gain = 30	Gain = 100	Gain = 300	Gain = 1000	Gain = 10	Other Fixed Gains
Zero Drift	0.001%	0.002%	0.0055%	0.016%	0.051%		
Linearity	0.002 %	0.002 %	0.002 %	0.002 %	0.002%		
Gain Adj. Resolution						0.01%	0.01%
Gain-to-Gain Error						none*	0.02%
Gain stability (per month)						0.01%	0.01%
Totals	0.003%	0.004 %	0.0075%	0.018%	0.053%	0.02%	0.04%

*Gain is calibrated at Gain = 10.

TABLE 2.2

TEMPERATURE COEFFICIENTS
(assuming 500 ohm source unbalance)

Error Factors	% of Full Scale Errors per °C					% of Reading Error per °C (any Gain)
	Gain = 10	Gain = 30	Gain = 100	Gain = 300	Gain = 1000	
Zero Drift	0.00023%	0.00048%	0.00135%	0.00385%	0.0126%	
Gain stability						0.001%
Totals	0.00023%	0.00048%	0.00135%	0.00385%	0.0126%	0.001%

2.7 APPLICATIONS

The 2470A is a direct-coupled Data Amplifier that provides highly-accurate, stable gains from 10 through 1000. The 2470A-M1 provides gains from 1 through 1000. The 2470A is useful in, though not necessarily limited to, the following applications.

2.7.1 Data Acquisition

High Input Resistance – The extremely high input resistance of the 2470A, 1000 megohms even at 95% relative humidity, permits transmission of dc and very low frequency ac input signals over exceptionally long input lines, without incurring a need for tedious accuracy correction for source or line resistance.

Common Mode Rejection (CMR) – Rejection of 60 Hz common mode signals by the 2470A is 120 db at gain of 30 or greater. At gains of 10 and 1, CMR at 60 Hz is 110 db and 90 db, respectively. CMR for dc is 120 db at all gain settings. This CMR performance holds for up to 1000 ohm source unbalance, assuring excellent immunity from common mode noise. At most gain settings, only a millionth of 60 Hz common mode noise at the input is converted to a differential error signal.

Linearity – 2470A linearity is ±0.002% for both polarities, yielding excellent accuracy for down-scale inputs, more useful dynamic range.

Overload Signalling – When the 2470A Data Amplifier is equipped with overload signal option M4, transducer failures that involve the open-circuiting of a bridge are detected immediately. Remedial steps can be taken before the transducer failure causes unnecessary loss of data.

Reliability – The 2470A Data Amplifier uses hermetically-sealed silicon transistors and high-quality components, in an overall design intended specifically to attain high reliability. As a result, the mean time between failures (MTBF) of the 2470A is predicted* (with 90% confidence) as 20,000 hours, over two years of continuous operation, when operated at 25°C ambient. High reliability provides the best assurance that good, complete data will be obtained in expensive-to-repeat tests.

*Using component-count techniques.

Operating Conditions – The 2470A operates as specified from 0 to 55°C ambient, and to 95% relative humidity. Rarely, if ever, will this instrument require special adaptation to its environment.

2.7.2 Load Buffering for Standard Cell (2470A-M1 with Gain of 1)

The 1000 megohm input resistance and 0.5 ohm output impedance of the 2470A makes this instrument extremely useful as a load buffer. After zeroing, the 2470A-M1 turned on and set for and calibrated at 1 volt at a gain of 1 can be used as a load buffer for a saturated standard cell. The

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before turning off power.
by feedback.

2.7.3 Analog Comparison

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2.7.4 Amplification for Instru

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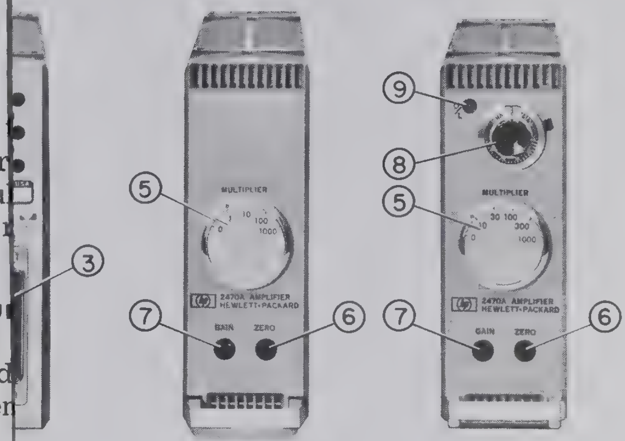

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7 GAIN (screwdriver) adjustment for calibrating gain of the 2470A. (The factory calibrates the 2470A at gain of 10.)

NOTE

See Figure 2.9 (page 2-11) for zeroing and gain calibration instructions.

8 Vernier (ten-turn) control on 2470A with M3 – used for multiplication of the fixed setting of the MULTIPLIER by a factor that is continuously variable from 1x to 3.5x.

9 O/L indicator on 2470A with M4 – lights when input voltage drives the amplifier output beyond full scale ±(10.5 to 12.5)v. (The O/L indicator also lights under the circumstances described in section 3.5.2, at the bottom of page 3-11.)

)F FRONT AND REAR PANELS

FIGURE 2.10

2.7 APPLICATIONS

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The 1000 megohm input resistance and 0.5 ohm output impedance of the 2470A makes this instrument extremely useful as a load buffer. After zeroing, the 2470A-M1 turned on and set for and calibrated at 1 volt at a gain of 1 can be used as a load buffer for a saturated standard cell. The

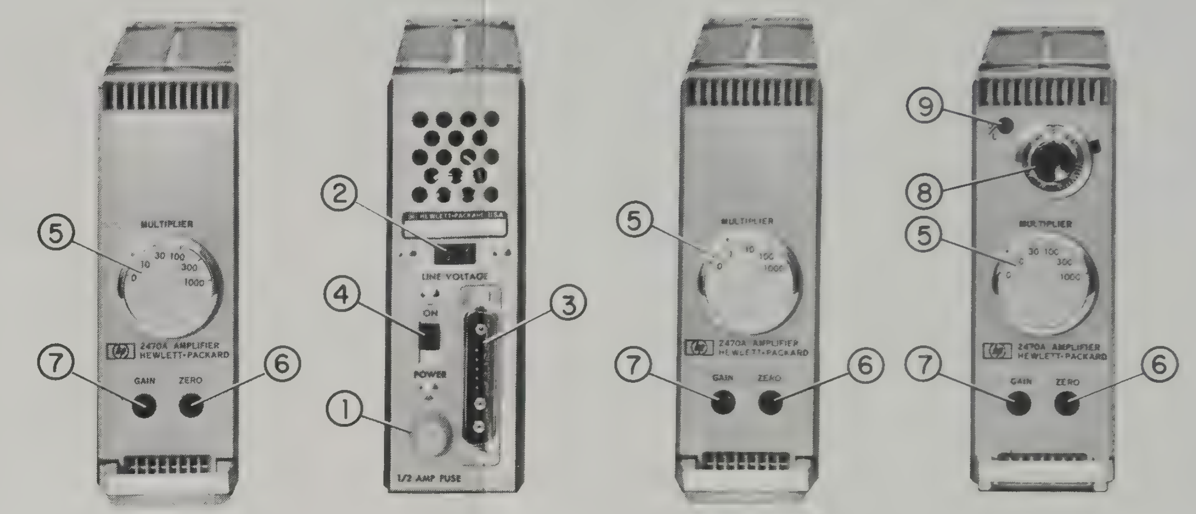
amplifier output can then be distributed as a house standard accurate to ±155 microvolts (approximately ±0.016% of output) in an 8 hour period assuming constant temperature. Disconnect the amplifier from the standard cell before turning off power. The 1000 megohm input resistance is achieved by feedback.

2.7.3 Analog Comparison

Differential input permits the 2470A to be used for amplifying the difference between two voltages referenced to a common ground. This permits setting an adjustable voltage to null with a known reference, the algebraic subtraction of two signals, and similar operations.

2.7.4 Amplification for Instruments

The amplification provided by the 2470A can be used to increase the sensitivity of accurate but insensitive voltmeters, oscilloscopes, oscillographs, and similar instruments. Usually the accuracy of the amplifier will equal or surpass the accuracy of the instruments it drives. However, differential source resistance greater than 1000 ohms can be expected to increase zero drift, and noise, reducing accuracy. (See section 2.2.8).



STD 2470A REAR PANEL 2470A-M1 2470A-M3,M4

1. Fuseholder with 1/2 amp fuse (BUSS GMW 1/2, HP Stock Number 2210-0046).
2. LINE VOLTAGE switch (for setting 2470A to operate from either 115 or 230 vac).
3. Power and signal input-output connector – mates with receptacles in rear of 12500A Combining Case, plug of 12501A Bench Stand or 12503A Cable Assembly, or 12502A plug.
4. POWER switch – controls ac power to 2470A.
5. MULTIPLIER (gain selector) switch with STD or M1 settings, as follows:
   STD settings: 0, 10, 30, 100, 300, 1000
   M1 settings: 0, 1, 10, 100, 1000
6. ZERO (screwdriver) adjustment for zero-setting the 2470A at gain of 1000.
7. GAIN (screwdriver) adjustment for calibrating gain of the 2470A. (The factory calibrates the 2470A at gain of 10.)

   NOTE

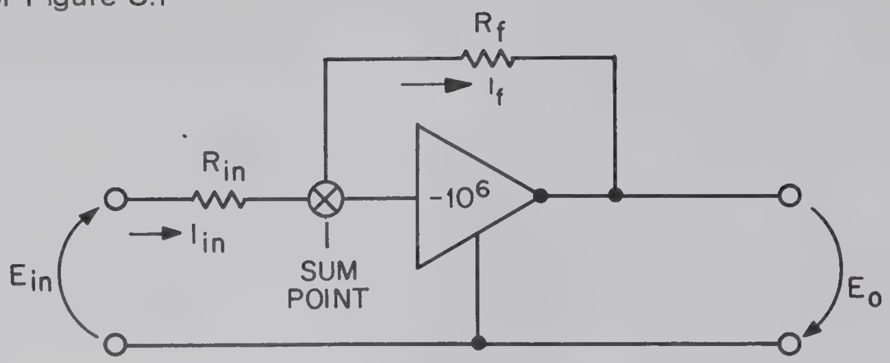
   See Figure 2.9 (page 2-11) for zeroing and gain calibration instructions.

8. Vernier (ten-turn) control on 2470A with M3 – used for multiplication of the fixed setting of the MULTIPLIER by a factor that is continuously variable from 1x to 3.5x.
9. O/L indicator on 2470A with M4 – lights when input voltage drives the amplifier output beyond full scale ±(10.5 to 12.5)v. (The O/L indicator also lights under the circumstances described in section 3.5.2, at the bottom of page 3-11.)

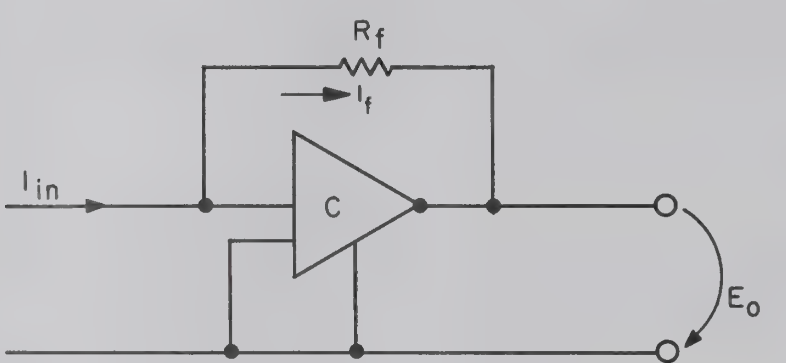
DESCRIPTION OF FRONT AND REAR PANELS

FIGURE 2.10

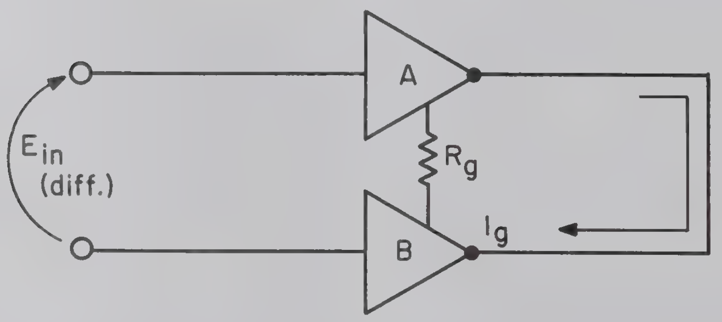
◀ Unfold for Figure 3.1



BASIC FEEDBACK AMPLIFIER
FIGURE 3.2



TRANSRESISTANCE AMPLIFIER
FIGURE 3.3



TRANSCONDUCTANCE AMPLIFIER
FIGURE 3.4

SECTION 3
THEORY OF OPERATION

3.1 OVERALL DESCRIPTION (Figures 3.1 through 3.4 - facing page)

The 2470A Data Amplifier (Figure 3. 1, facing page) is a differential design that consists of three amplifiers. These amplifiers, identified A-B-C for convenient discussion, have open-loop gain of -10^6 at dc, and controlled rolloff for minimum noise consistent with other design objectives. Open-loop input resistance of these amplifiers is greater than 100K.

Because their gain is very high (-10^6), any of amplifiers A, B, or C could be connected as a basic feedback amplifier (Figure 3. 2). Amplifier input voltage at the sum point (E_{sp}) is extremely small (virtually zero) for any output voltage (E_o) within the dynamic range of the amplifier. Because amplifier input resistance is high (greater than 100K) and E_{sp} is virtually zero, amplifier input current (I_{sp}) also is virtually zero. Thus:

$$\text{Voltage Gain (closed loop)} = \frac{E_o}{E_{in}} = \frac{R_f \cdot I_f}{R_{in} \cdot I_{in}} = \frac{R_f}{R_{in}}$$

* Because $I_f = I_{in}$ (I_{sp} is virtually zero)

The input resistance of the basic feedback amplifier (Figure 3.2) is R_{in}, since the sum point is a virtual ground. To make possible very high input impedance with low noise, the 2470A "Post" amplifier (amplifier C) is operated in "transresistance" configuration (Figure 3. 3), with I_{in} supplied by the Preamplifier. The following expression defines operation of this amplifier:

$$\text{Transresistance} = \frac{E_o}{I_f} = R_f$$

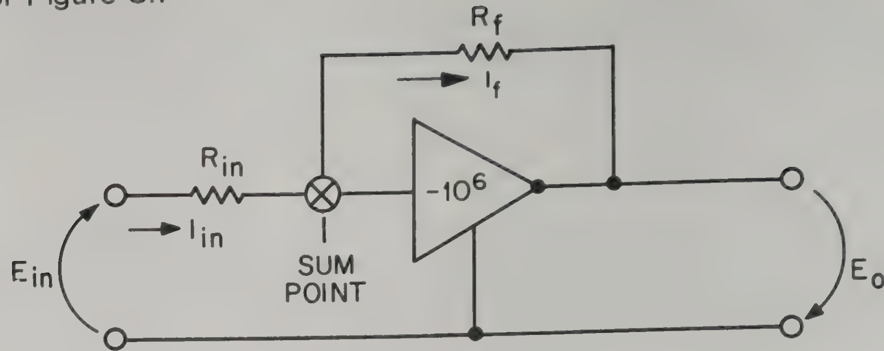
Signal current for the "post" amplifier is supplied by amplifiers A and B, which form a transconductance Preamplifier (Figure 3. 4). This amplifier supplies a short-circuit current, I_g, that is proportional to E_{in} and the value of R_g. Because the outputs of amplifiers A and B are shorted, E_{in} is developed across R_g. The operation of this amplifier is defined by:

$$\text{Transconductance} = \frac{I_g}{E_{in}} = \frac{1}{R_g}$$

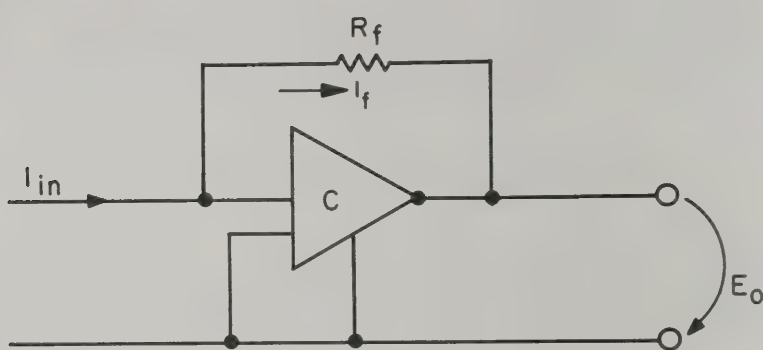
When the transconductance Preamplifier is connected to the transresistance "Post" amplifier, the feedback current (I_f) is essentially equal to the I_g current from the Preamplifier. This satisfies the Preamplifier's requirement for shorted output (Figure 3. 4). The individual performances of the Preamplifier and "Post" amplifier combine as follows to yield the equation for overall gain of the 2470A:

$$\begin{array}{l}\text{Preamplifier}\\ \text{Transconductance}\end{array} = \frac{I_g}{E_{in}} = \frac{1}{R_g} \qquad \begin{array}{l}\text{"Post" amplifier}\\ \text{Transresistance}\end{array} = \frac{E_o}{I_f} = R_f$$

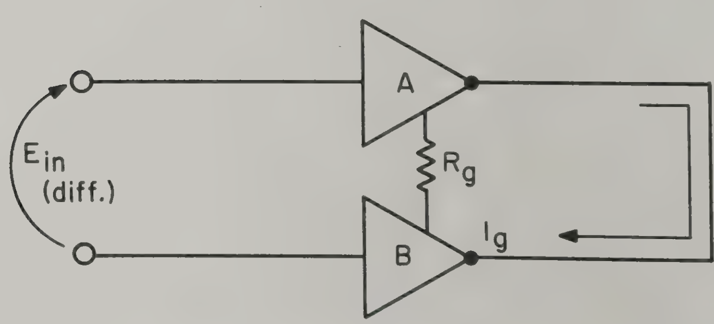
◀ Unfold for Figure 3.1



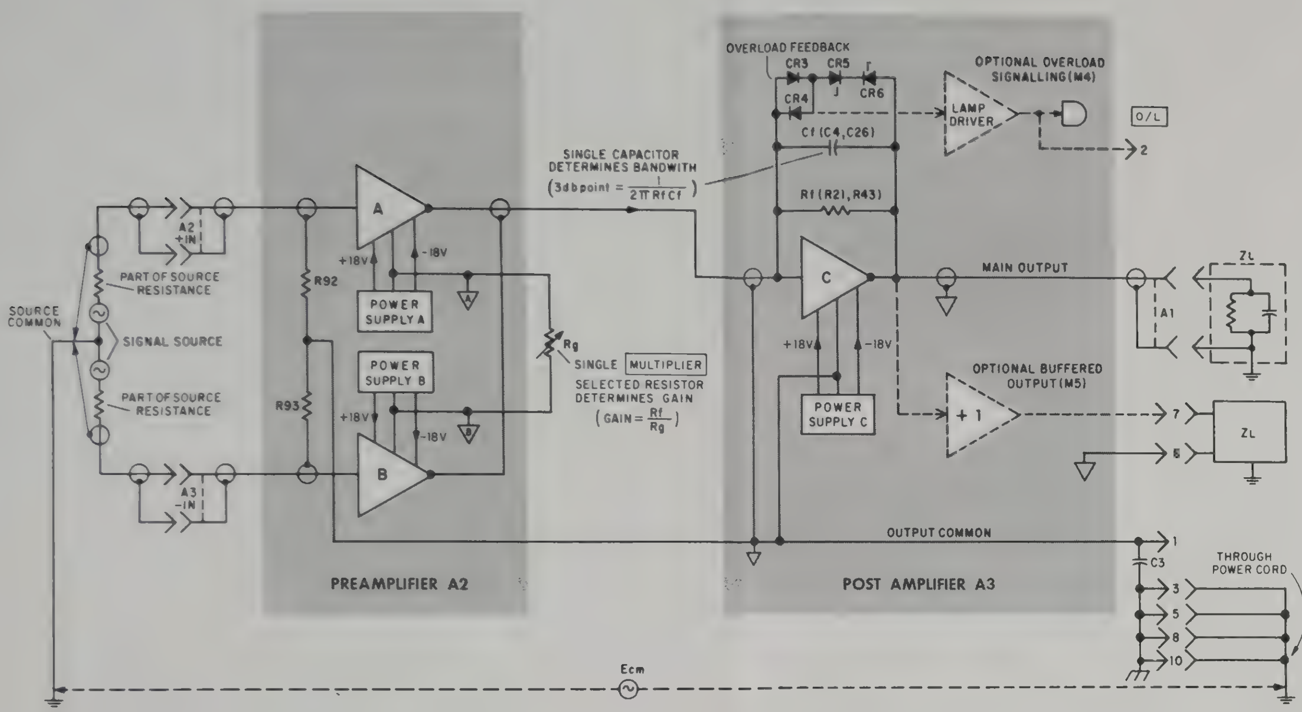
BASIC FEEDBACK AMPLIFIER
FIGURE 3.2



TRANSRESISTANCE AMPLIFIER
FIGURE 3.3



TRANSCONDUCTANCE AMPLIFIER
FIGURE 3.4



2470A FUNCTIONAL DIAGRAM
FIGURE 3.1

$$\text{Voltage Gain} = \frac{E_o}{E_{in}} = \frac{R_f I_f}{R_g I_g} = \frac{R_f}{R_g} \quad (\text{since } I_f = I_g)$$

In 2470A amplifiers without vernier option M3, R_f is a fixed value resistor that is trimmed to calibrate gain. R_g is selected by the front panel MULTIPLIER switch. The standard 2470A provides five precise R_g values for gains of 10, 30, 100, 300, and 1000. The 2470A with M1 has four precise R_g values, providing gains of 1, 10, 100, and 1000. The vernier is in series with R_f in 2470A amplifiers with M3. Clockwise adjustment of the vernier increases R_f, thereby increasing voltage gain.

The bandwidth of the 2470A is determined by the value of C_f in parallel with R_f. Gain is 3 db down at the frequency at which the capacitive reactance (X_c) of C_f equals the resistance of R_f. Because of this relationship, vernier-multiplied gain, which increases R_f, reduces the -3 db (cutoff) frequency of the 2470A-M3. The standard bandwidth of the 2470A ranges from dc to a 3 db cutoff frequency of 50 Khz ±10%. The ±10% tolerance results from the tolerance of capacitor C_f and some secondary effects.

The 2470A is equipped with an overload feedback network that reduces overall gain enough to hold the output constant at ±(10.5 to 12.5) volts if the input signal exceeds full scale at the selected gain. The overload feedback prevents saturation of amplifier C, assuring rapid overload recovery.

In 2470A amplifiers with M4, an O/L lamp and overload detector-driver circuit are added to provide overload signalling. The overload circuit switches on the O/L lamp in response to input signals of either polarity that are greater than full scale. This circuit also signals overload if the output is short-circuited, the amplifier is oscillating or slew limited, if the input guard is not correctly terminated, or if some part of the amplifier has failed. Turn-on of the O/L lamp also provides an overload signal that can be used to activate an alarm or a remote indicator.

In 2470A amplifiers with M5, a fourth amplifier with +1 gain provides a second, buffered output. The buffered output follows the main outout, but has only negligible loading effect upon the main output even if short circuited. The buffered output can also have a narrower bandwidth than the main output, with 2-pole, 12 db-per-octave rolloff.

An inherent requirement of direct-coupled data amplifiers, a dc return between input (source) common and output common, is completed in the 2470A through R92 and R93 of the preamplifier when the guard shields of the coaxial inputs are connected to the input.

3.2 COMMON MODE REJECTION (CMR)

Rejection of common mode signal voltage (E_{cm}) existing between source common and output ground is set at 120 db (one million to one) by the open loop gain of transconductance amplifiers A and B (-10^6).

Because amplifiers A and B have equal gain:

$$CMR = \frac{K_A \bullet R_{in}}{R_g + R_{iu}}$$

Where: K_A = open-loop gain of amplifier A or B

R_{in} = open-loop input resistance of the 2470A

R_{iu} = input unbalance

The relationship presented above is valid only because amplifiers A, B, and C are powered by supplies that are completely isolated from each other. The only connection between power supplies A, B, and C is through the corresponding amplifiers and through R_g. This isolation is assured by driving the individual supplies with ac power from three separately shielded secondaries of the power transformer. Insulation between windings and between the power supplies is so high that leakage current between supplies is less than 10 nanoamperes. Guarded capacitances are less than 0. 25 picofarads.

3.3 MULTIPLIER SWITCH ASSEMBLY A1 (Figures 5.1 and 5.4)

NOTE

Unless otherwise specified, incomplete reference designations (R1, S1, C1, Q1, CR1, etc.) in the following descriptions (sections 3.3 through 3.5.4) pertain to components of the assembly being described.

MULTIPLIER switch assembly A1 selects the gain-determining resistor, R_g, that connects amplifier A common to amplifier B common. The external connections and schematics of A1 are shown in Figures 5. 1 and 5. 4. A1 consists of four-pole rotary switch S1, five (std 2470A) or four (2470A-M1) precision R_g resistors, and a buss lug . The R_g resistance values are accurate to ±0. 01% and have excellent temperature stability (±5 ppm per °C). The precision of these resistors assures that gain-to-gain error cannot exceed ±0. 02%. (Gain-to-gain error equals ±0. 02% only when the resistor for the calibrated gain is +0.01% and that for another gain is -0.01%, or vice versa.)

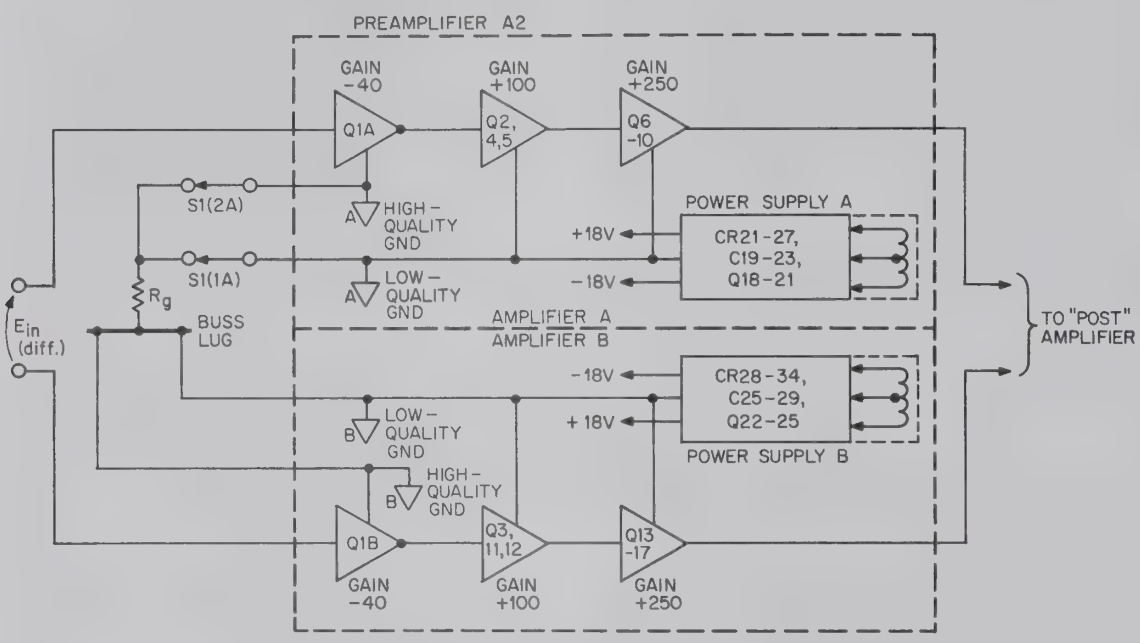
The design and construction of the MULTIPLIER switch assembly preserve the resistor accuracy by separately connecting the high-quality and low-quality grounds of the preamplifier to the selected R_g resistor. This technique (similar to the four-wire connection used for highly-accurate resistance measurement by the HP-2410B/HP-2401C digital ohmmeter) eliminates the effects of switch contact resistance and lead length.

In all gain-selecting positions of S1, the 2470A output from the "Post" amplifier is connected to coaxial contact J1A1 of the rear panel connector through switch section 1B. When S1 is set to "0" position, the "Post" amplifier

output is disconnected and the center contact of J1A1 is shorted to the shell (output common) for convenient zeroing of the instrument that is connected to the 2470A output. The "0" position does not disconnect the 2470A input leads from the signal source.

3.4 PREAMPLIFIER ASSEMBLY A2 (Figures 3.5, 3.6, and 5.4)

As noted previously (sections 3.1 and 3.2), the Preamplifier consists of identical amplifiers A and B and identical, completely isolated power supplies A and B. (See Figures 3.5 and 5.4.)



PREAMPLIFIER ASSEMBLY A2, FUNCTIONAL DIAGRAM

FIGURE 3.5

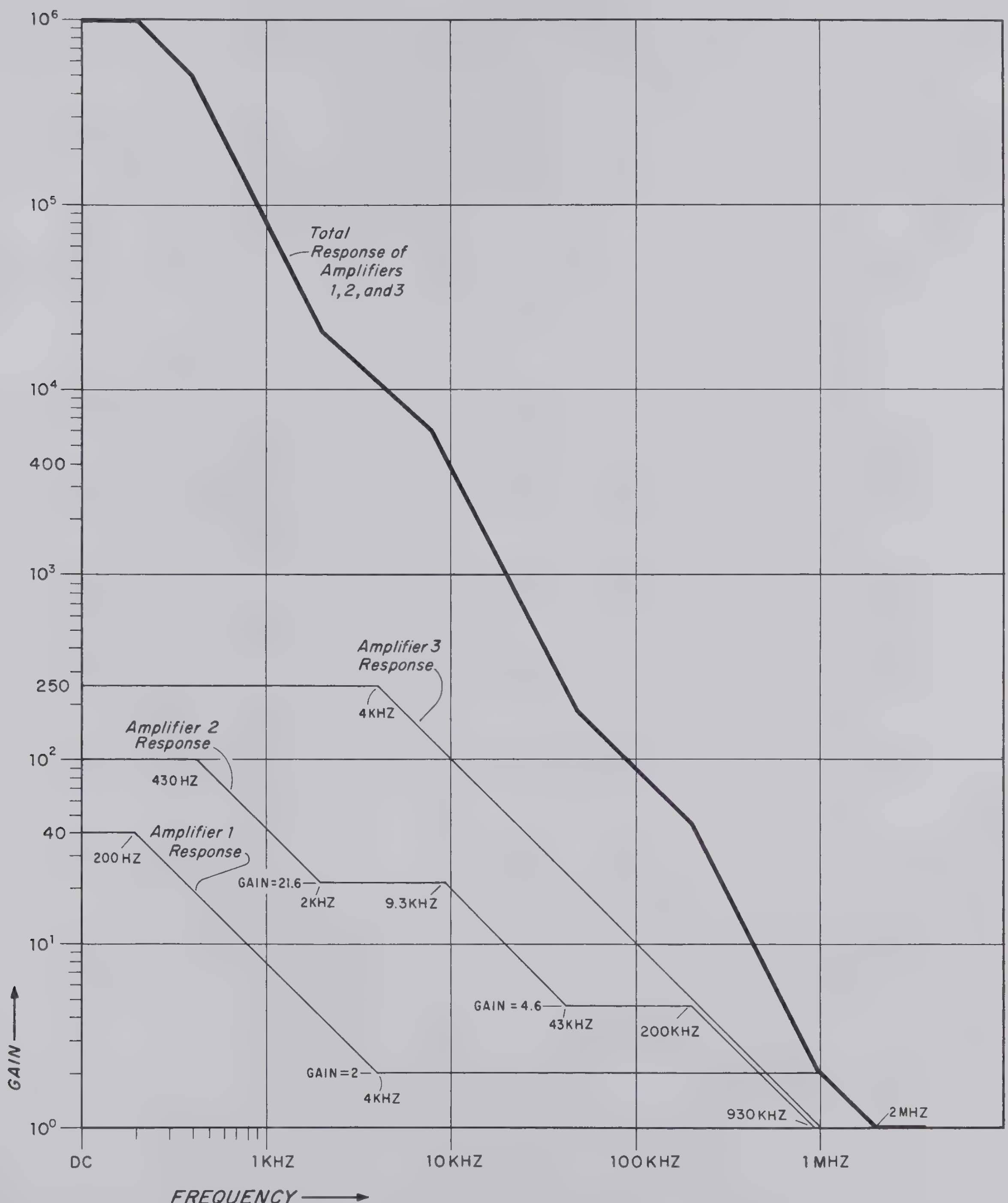
3.4.1 Amplifier A

Amplifier A actually consists of three cascaded amplifiers, with gains of -40, +100, and +250. The minus sign in front of the gain of 40 denotes inversion; inversion is also indicated independently by the dot at the output of the gain of -40 amplifier symbol (Figure 3.5). The circuit details of the individual amplifiers are discussed in the following paragraphs.

First Amplifier

The first amplifier consists of transistor Q1A and related circuit elements. This common-emitter amplifier is powered by +6.2 volts that is regulated in isolation from the main supply with respect to high-quality ground A by voltage reference diode CR6. Amplifier Q1A is biased class A through resistors

R3, R5, and variable resistor R4, the rti offset current null adjustment. The gain of Q1A is -40 from dc to the -3 db point (200 hz); thereafter r-c (resistance-capacitance) network R11-C1 rolls off gain at a rate of 6 db per octave. The response of the first amplifier is plotted in Figure 3.6. Diode CR5 connected between the base and emitter protects Q1A from reverse bias punch-through in the event of overload.



AMPLIFIER A RESPONSE CURVES (IDEALIZED)
FIGURE 3.6

Second Amplifier

The second amplifier consists of transistors Q2, Q4, and Q5, and related circuit elements. The transistors are connected in differential configuration, Q2A with Q2B and Q4 with Q5. The bias applied to the transistors of each differential pair is identical. Temperature-induced changes of bias on one transistor is cancëlled by like changes of bias on the companion transistor. In effect, temperature-induced bias changes become a common mode signal that is greatly attenuated, assuring minimum drift. A dual transistor is used for the first differential stage to assure that the transistors share the same temperature environment as nearly as possible.

The gain-bandwidth characteristics of the second amplifier are determined by r-c feedback from the collector of Q4 to the emitter of Q2A via R20, R21-C4, R22-C5, and C3. See Figure 3.6 for response of amplifier 2.

Diodes CR7 and CR8, connected between the collectors of Q2A and Q2B, keep the input to Q4-Q5 from exceeding ±0.4 to 0.7 volts differential. This limits saturation of subsequent circuits in the event of overload.

Third Amplifier

The third amplifier consists of common-emitter stages Q6 and Q7, a complementary push-pull output stage, Q9-Q10, a constant-current coupling network, CR9-CR10-Q8, and related circuit elements. The collector current from Q8 is held constant at approximately 6 milliamperes by the (R30-R31) divider-developed voltage at the base and by the value of emitter resistor R32. Constant current maintains a constant voltage across diodes CR9 and CR10 so that signal voltages at the Q7 collector are coupled, without attenuation, to the base of Q10 as well as to the base of Q9. The voltage drop across CR9 and CR10 forward biases both Q9 and Q10 slightly, avoiding crossover distortion (which would result if one transistor cut off before the other turned on.)

The gain of the third amplifier is +250 from dc to the -3 db point (4 Khz); thereafter feedback coupled through C8 rolls off gain at a rate of 6 db per octave. Gain is down to +1 at 1 Mhz. (See Figure 3.6.)

3.4.2 Amplifier B

Amplifier B is identical to amplifier A, except for the coarse and fine zero adjustments in the bias circuit of Q3B (corresponds to Q2B of amplifier A). The coarse zero adjustment is R45 and the fine adjustment is R46, which is the front panel ZERO setting.

3.4.3 Overall Operation

The differential input signal path for otherwise separate amplifiers A and B is completed through MULTIPLIER-selected resistor R_g. Differential signal current proportional to E_{in} flows through R_g. The differential output current drives the "Post" amplifier. Feedback current (I_f) from the "Post" amplifier output almost exactly balances the Preamplifier output current. Thus, the

Preamplifier supplies its output to a virtual short circuit. The signal current passing between the A and B grounds through R_g develops a voltage drop across R_g that is almost exactly equal to E_{in}. This current feedback holds the differential signal current through the base-emitters of Q1A and Q1B to an extremely small value, producing an extremely high effective input resistance. The theoretical input resistance is given by the following expression:

$$R_{in\,(diff)} = R_{in(A)} \text{ times Gain}$$

Since $R_{in(A)}$, the open-loop input resistance of amplifier A or B, is greater than 100K and gain is one million, the theoretical differential input resistance is greater than 100, 000 megohms. However, insulation resistance is considerably lower, particularly at high humidity. So the effective differential input resistance of the 2470A is not 100, 000 megohms, but is greater than 1000 megohms, even at 95% relative humidity.

In addition to circuits already discussed, the preamplifier includes current-limiting resistors R1 and R38, which limit current through the Q1A and Q1B base-emitters and diodes CR5 and CR15. This action becomes necessary if greater than ±11 volts is applied to the input.

Capacitors C32, C33, and C34 form a low-pass filter with R1 and R38. This filter has negligible effect upon signals within the passband of the amplifier, but attenuates radio frequency interference starting at approximately 100 KHz.

Capacitor C17 is necessary because the Preamplifier is designed to work into the virtual short circuit presented by current feedback from the "Post" amplifier. When current feedback falls off, as it does at higher frequencies, the Preamplifier tends to become unstable. High frequency instability is prevented by C17 because it presents a very low X_c and a virtual short circuit to signal frequencies above 100 Khz.

3.4.4 Power Supplies (Figures 3.5 and 5.2)

The two preamplifier power supplies are identical circuits, each referenced to its own common and fully isolated from the other, and from the "Post" amplifier power supply. The supplies are driven by ac power from separate, well-shielded secondaries of the 2470A power transformer.

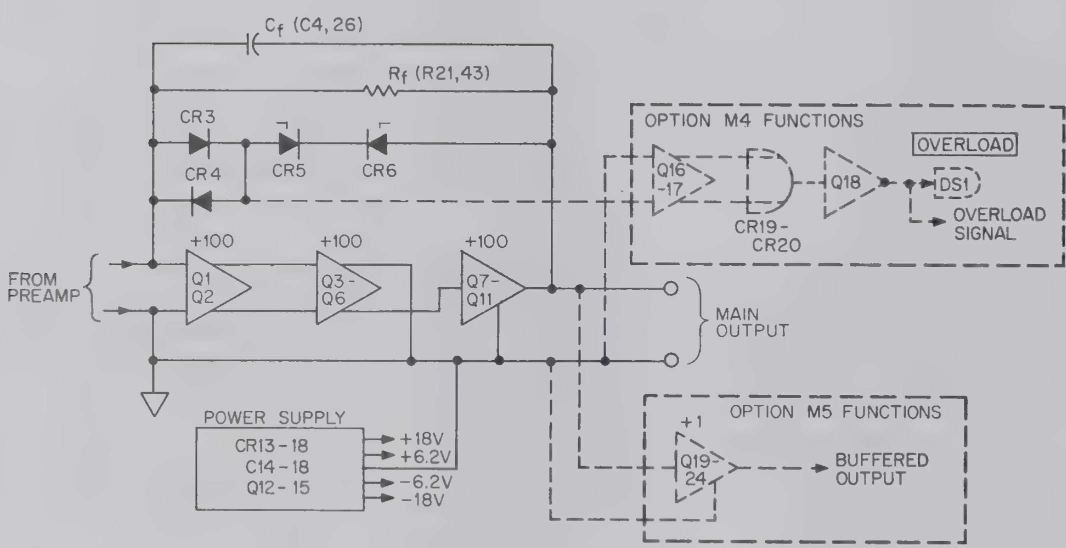
Power supply A is typical. The ac input from the power transformer secondary is rectified by CR24-27, filtered by C22 and C23, and regulated by transistors Q18-21. Voltage reference diode CR23 and voltage reference diodes CR21 and CR22 break down at approximately 18 volts, causing the ±18 volt regulators to stabilize at an output of 18. 5 ±1 volts with respect to common. Output variations, including ripple voltage, are coupled to dc amplifier Q20 or Q21 through CR23 or CR21 and CR22. Negative feedback that greatly attenuates ripple voltage and keeps output voltage essentially constant is provided by the amplified and inverted outputs from the collectors of Q20 and Q21, which are applied to the bases of series regulators Q18 and Q19.

3.5 'POST' AMPLIFIER ASSEMBLY A3 (Figures 3.7, 3.8, and 5.6)

The "Post" amplifier assembly consists of the basic "Post" amplifier, the overload signalling circuit (in 2470A with M4), a second, buffered output (in 2470A with M5), and a power supply. These functional elements are shown in Figure 3. 7. The "Post" amplifier schematic is Figure 5. 6.

3.5.1 Basic 'Post' Amplifier

The basic "Post" amplifier actually consists of three cascaded amplifiers, all with gain of +100. (See Figures 3. 7 and 5. 6) The first two amplifiers have differential input and differential output. The inversion required by the 2470A design is provided by cross-coupling the outputs of the second amplifier to ground and to the input stage of the third amplifier. The circuit details of the individual amplifiers are discussed in the following paragraphs.



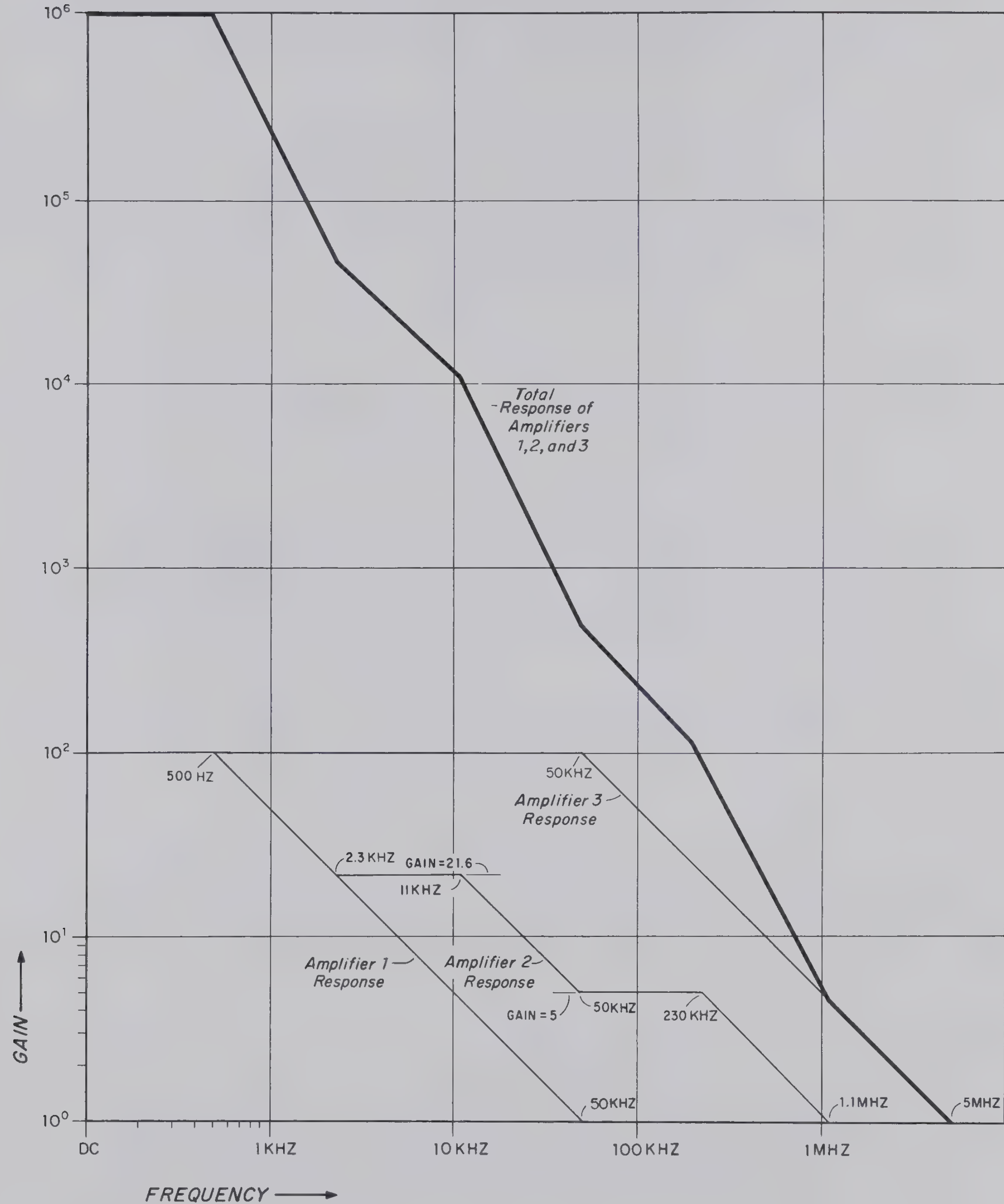
'POST' AMPLIFIER ASSEMBLY, SIMPLIFIED FUNCTIONAL DIAGRAM

FIGURE 3.7

First Amplifier

The first amplifier is a two-stage differential type consisting of dual transistors Q1A/B and Q2A/B and related circuit elements. With differential input, temperature-induced changes of bias effectively become a common mode signal that is greatly attenuated. Second stage Q2A/B is balanced by adjustment of variable resistor R28. The input stage is balanced by R11. The base currents of Q1A and Q1B are nulled by means of R4 and R6. The gain of the first amplifier is +100 from dc to the -3 db point (500 hz). Thereafter r-c (resistance-capacitance) networks C5-R25 and C6-R26 roll off gain at a rate of 6 db per octave. Gain is down to +1 at 50 Khz, then flat beyond 5 Mhz. (See Figure 3. 8.)

Diode clipper stages CR29-CR30-R107 and CR1-CR2 limit signal amplitude at the first amplifier input. This adds to the overload protection already provided by the overload feedback network from the output to the input of the "Post" amplifier.



POST AMPLIFIER RESPONSE CURVES (IDEALIZED)
FIGURE 3.8

Second Amplifier

The second amplifier consists of transistors Q3 through Q6, connected as a two-stage differential feedback pair, and related circuit elements. The output from the Q5 collector, which is in-phase with respect to the high side of the Preamplifier input, is grounded. The output from the Q4 collector, which is inverted with respect to the high side of the Preamplifier input, is applied to the third amplifier. This connection inverts the "Post" amplifier output with respect to the input.

The gain-bandwidth characteristics of the second amplifier are determined by r-c (resistance-capacitance) feedback from the collectors of Q5 and Q6 to the emitters of Q3 and Q4. Feedback from the Q5 collector is coupled through R47, R46-C9, R45-C8, and C7. Feedback to the Q4 emitter is coupled through R48, R49-C10, R50-C11, and C12. The overall response of the second differential feedback pair is diagrammed in Figure 3. 8.

Third Amplifier

The third amplifier consists of common-emitter stages Q7 and Q8, a complementary push-pull output stage, Q9-10, a constant-current coupling network, CR11-CR12-Q11, and related circuit elements. The collector current from Q11 is held constant at approximately 12. 5 milliamperes by the (R63-R64) divider-developed voltage at the base and by the value of emitter resistor R62. Constant current maintains a constant voltage across diodes CR11 and CR12 so that signal voltages from the Q8 collector are coupled, without attenuation, to the base of Q10 as well as the base of Q9. The voltage drop across diodes CR11 and CR12 forward biases both Q9 and Q10 slightly, avoiding crossover distortion (which would result if one transistor cut off before the other turned on).

The gain of the third amplifier is +100 from dc to the -3 db point (50 Khz); thereafter feedback coupled through C13 rolls off gain at a rate of 6 db per octave. Gain is down to +1 at 5 Mhz. (See Figure 3. 8.)

Inductor L1 decouples the output of Q9-Q10, which is the output of the 2470A, from the capacitance of any length of cabling that may be connected. This decoupling avoids the instability that is sometimes characteristic of direct-coupled data amplifiers when they are called upon to drive considerable lengths of coaxial or shielded cabling. Resistor R69 in parallel with L1 damps any oscillation that might be supported by that inductor.

Gain and Bandwidth Control Feedback

DC feedback from the output of the third amplifier to the input of the first is coupled through fixed resistor R21 and the GAIN trim adjustment, variable resistor R43. AC feedback is coupled through C4, rolling off gain at 6 db per octave above 50 Khz (±10%) in standard 2470A Data Amplifiers. When capacitor C26 is connected in parallel with C4, the amplifier's cutoff frequency is reduced; the actual frequency depends upon the value of C26. See the "Post" amplifier parts list (page 5-11) for a C26 value - versus - cutoff frequency tabulation.

Overload Control Feedback

Overload control feedback from the output of the third amplifier to the input of the first amplifier is coupled through diode CR3 or CR4 and voltage breakdown diodes CR5 and CR6 when the output voltage of the third amplifier exceeds ±10.5 volts for any reason. This feedback acts to hold the output voltage of the third amplifier (and the 2470A) at the previously-specified potential and also prevents saturation of the "Post" amplifier, assuring rapid recovery from overload.

3.5.2 Overload Signal Option M4 (Figures 3.7 and 5.6)

Overload signal option M4 consists of differential amplifier Q16-17, OR gate CR19-20, lamp and signal switch Q18, O/L indicator lamp DS1, and related circuit elements. While the output of the 2470A is such that no current flows through CR3 or CR4 of the overload feedback network, Q16 and Q17 are equally forward biased, with their collector voltages balanced as set by variable resistor R79. With the differential amplifier balanced, collector voltages of Q16 and Q17 are positive with respect to ground and both OR gate diodes are cut off by reverse bias. With no input from diode CR19 or CR20, switch Q18 is cut off, and the overload signal output line is at -17.5 to -18.5 volts.

Conduction through overload feedback diode CR3 or CR4 produces a voltage drop that unbalances the differential amplifier. Negative voltage drop across CR3 in the forward direction increases conduction through Q16 and reduces current through Q17. The Q17 collector voltage becomes negative enough to forward bias OR gate diode CR19, turning on switch Q18 through isolation diode CR21. Positive voltage drop across CR4 in the forward direction reduces conduction through Q16 enough that the Q16 collector voltage goes negative, forward-biasing OR gate diode CR20, isolation diode CR21, and switch Q18. Turn-on of Q18 lights the O/L indicator lamp and pulls the overload signal line to near ground potential.

The O/L indicator is lighted under the following circumstances:

1. When the "Post" amplifier is driven to produce an output greater than ±10.5 volts, diode CR5 or CR6 breaks down in the reverse direction resulting in conduction through CR3 or CR4, which activates the overload signal circuit.
2. When the output is short-circuited, the input voltage rises to the point where CR3 or CR4 becomes forward biased, developing a voltage across resistor R23 that is sufficient to activate the overload signal circuit.
3. Non-linear operation of the amplifier, such as in oscillation or slew limiting, also raises input voltage enough to forward bias CR3 or CR4. This develops sufficient voltage across resistor R23 to activate the overload signal circuit.
4. If the input guard is not correctly terminated, or if some part of the amplifier has failed, the "Post" amplifier output often goes to the overload limit voltage (±10.5 volts), which has the same effect as an input signal that exceeds full scale. Breakdown of CR5 or CR6 results in conduction through CR3 or CR4, activating the overload signal circuit.

3.5.3 Buffered Second Output - Option M5 (Figures 3.7 and 5.6)

The buffered second output is produced by a +1 amplifier. The input is coupled through an isolation and response shaping network (R85-C20-R87) to one side of a differential stage, Q19A-B. The other side of this stage receives gain-determining negative feedback from the output. DC emitter current (about 250 microamperes) for Q19A-B is supplied by regulator Q20 via the zero set adjustment, variable resistor R93. The output of Q19A-B is coupled directly from the Q19A collector to the base of common-emitter amplifier Q21. The output from the Q21 collector is coupled to a complementary push-pull output stage, Q23-24, through a constant current network consisting of CR22-CR23-Q22. The voltage drop across diodes CR22 and CR23 forward biases both Q23 and Q24 slightly, avoiding crossover distortion.

The dc gain of the buffered output amplifier is determined by negative feedback from the output to the base of Q19B through R90. The exact amplitude of this voltage feedback is set by variable resistor R104, which is the gain trim adjustment. The overall gain of the buffered output with respect to the main output is +1 from dc to the -3 db point (cutoff frequency). Thereafter gain rolls off at the rate of 12 db per octave. The cutoff frequency of the buffered output cannot be greater than the cutoff frequency of the main output, but can be less. The actual cutoff frequency is determined by the values of C20, C21, and C22. See the A3M5 section of the "Post" amplifier parts list (pages 5-13 and 5-14) tabulations of C20, C21, and C22 values versus buffered output bandwidth.

3.5.4 Power Supply (Figure 5.6)

AC voltage from the third secondary of the power transformer is rectified by CR13-16, filtered by C14 and C15, and regulated by transistors Q12-15. Voltage reference diodes CR17 and CR18 break down at approximately 18 volts, causing the ±18 volt regulators to stabilize at an output of 18.5 ±1 volts with respect to output common. Output variations, including ripple voltage are coupled to dc amplifier Q12 or Q13 through CR17 or CR18. Negative feedback that greatly attenuates ripple voltage and keeps output voltage essentially constant is provided by the amplified and inverted outputs from the collectors of Q12 and Q13, which are applied to the bases of series regulators Q15 and Q14. Shunt regulators CR7 and CR8, connected in series with current limiting resistors R29 and R30, provide regulated ±6.2 volts, which is applied to bias and zero-setting networks of the first amplifier.

SECTION 4
MAINTENANCE

4.1 GENERAL

This section contains instructions for maintenance of the 2470A Data Amplifier. Included are a list of recommended test equipment (Table 4.1), a maintenance schedule (Table 4.2), in-cabinet performance checks (Table 4.3), and instructions for access to assemblies, troubleshooting, repair, cleaning, and calibration. Parts locations and schematic diagrams are in Section 5 with the parts lists.

NOTE

If it should become necessary to communicate with the factory or your Hewlett-Packard Field Service Facility regarding your 2470A, be sure to specify the instrument's complete serial number and all modification (M) numbers.

4.2 IN-CABINET PERFORMANCE CHECKS AND TEST CARD

The in-cabinet performance checks in Table 4.3 may be used to verify specifications of the 2470A. The Performance Check Test Card at the end of Table 4.3 may be filled out to provide a permanent record of the instrument's performance. Separate columns on the test card are provided for entry of measurement result(s) and whether the result is acceptable. The determination of result acceptability is based upon the limits entered in a 'specification limits' column. The entry numbering on the test card corresponds to the check numbers and step in Table 4.3. The checks in Table 4.3 may be used to verify all important performance specifications for the following purposes:

1. As part of an incoming inspection check of instrument specifications.
2. Periodically, as specified in Table 4.2, to verify correct operation.
3. After repairs and adjustments, to verify correct operation before returning the 2470A to regular service.

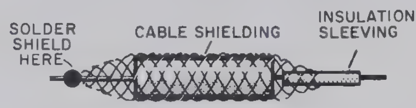
NOTE A

The 2470A Data Amplifier is a highly-sensitive precision instrument whose performance must be checked carefully to assure valid results. For example, clips making intermittent contact with test voltage sources may violate the requirement for 1K source resistance. In extreme instances, intermittent input connections may even cause the 2470A to be self-driven to an overload-limited output that does not respond to variation of the input voltage.

TABLE 4.1
RECOMMENDED TEST EQUIPMENT

Equipment	Required Characteristics and Use	Recommended Model or Equivalent
Combining Case and Cable Assembly	Power and signal input-output connections, including wires from Pins 1, 2, 6, and 7 of plug where required to check 2420A with M4 or M5.	HP-12500A Combining Case and HP-12503A Cable Assembly
Variable Power Supply	Adjustable 0 to 20vdc output for performance checks.	HP-721A Power Supply
DC Vacuum Tube Volt-Ammeter	Voltage measurements to ±30vdc full scale and current measurements to ±300 ma full scale for performance checks.	HP-412A DC Voltmeter-Ohmmeter-Ammeter
100 ohm load	Load for 2470A main output during performance checks	Any 100 ohm, 5w resistor
1000 ohm load	Load for 2470A-M5 buffered output	Any 1K, 1/2 w resistor
Audio Oscillator	Variable output up to 10v from 10Hz to 100 Khz for performance checks	HP-200CD or 202C Oscillator
Wide range AC Voltmeter	RMS readings on 1, 3, and 10mv and 1v and 10v ranges over 20Hz to 50Khz frequency range for performance checks	HP-3400A RMS Voltmeter (preferred) or HP-400D, 400E/EL, 400F/FL, 400H, or 400L AC VTVM
Oscillator output divider	Divides 600 ohm output of audio oscillator to provide approximately 50 ohm output impedance for performance checks	560 ohm resistor in series with 56 ohm resistor, both 1/2 w
Oscilloscope	Maximum sensitivity of 1mv/cm, 400Khz bandwidth, A-B and dc input capability, sweep times from .5μs/cm to 50ms/cm, and 1v and 10v square wave calibration outputs for performance checks and general signal tracing	HP-140A Oscilloscope with HP-1420A Time Base and HP-1402A Dual-Trace Preamplifier
Null Voltmeter	Differential measurements from 100μv to 30v dc full scale for performance checks, signal tracing, and calibration	HP-419A DC Null Voltmeter

TABLE 4.1 (Cont'd)

Equipment	Required Characteristics and Use	Recommended Model or Equivalent
Shielded unbalance resistor	1K deposited carbon resistor with copper leads, shielded as indicated below - for performance checks 	Any good quality deposited carbon resistor with copper leads
High-Sensitivity Oscilloscope Preamplifier *	10mv/cm sensitivity for noise performance check of 2470A having bandwidth less than 1 KHz	HP-1403A Guarded Differential Amplifier plug-in for HP-140A or 141A Oscilloscope
Precision Divider	Constant 100K input resistance, 5ppm accuracy, switch-selected decimal fraction multipliers for performance checks and calibration	Electro-Scientific Industries model RV722A Dekavider
Shorting Plug	GR dual banana plug with solid copper wire connected between plug contacts	As described at left
Bypassed unbalance resistor	10K deposited carbon resistor with copper leads, bypassed with a .001μf parallel-connected capacitor for internal zeroing of the 2470A	As described at left
Coaxial cable GR-GR	44 inch long for various test setup connections	HP-11000A Cable Assembly
BNC-GR adapter (2 required)	Various test setup connections	HP-10110A BNC to Banana Post Adapter
Test Leads	60 inch long pair for various test setup connections	HP-11002A Test Leads
Inductor	120μh inductor for zeroing 'Post' amplifier with small alligator clips connected to both leads	As described at left
Jumpers	Two short clip leads for troubleshooting and 'Post' amplifier zeroing	As described at left

* Required only if 2470A being checked has main BW < 1Khz

NOTE B

The 2470A must be positioned (upright or on its side) as it was during calibration. Changing the instrument's attitude when it is operated in free air (without forced air ventilation through the 2470A from rear to front at 1 cubic foot per minute, minimum) changes internal temperature gradients, affecting calibration.

NOTE C

Zero drift referred to the input may be up to 10 μv greater than the figure for operation in the Combining Case when the 2470A is operated in free air (as defined in Note B). Consequently, when checking an instrument operated in free air, use the larger specification limits quoted for zero drift checks where two limits are quoted.

TABLE 4.2

MAINTENANCE SCHEDULE

Recommended Interval	Maintenance Operation
Daily or before data run	Zero and calibrate the 2470A as instructed in Figure 2-9.
Quarterly (every 90 days)	Calibrate internal adjustments as instructed in applicable paragraphs 4. 7. 1 through 4. 7. 5.
Semi-annually (every 180 days)	Vacuum the inside of the 2470A in a clean atmosphere. Do not use an air blast.
	Check performance of the 2470A as instructed in Table 4. 3, checks 1 through 9.

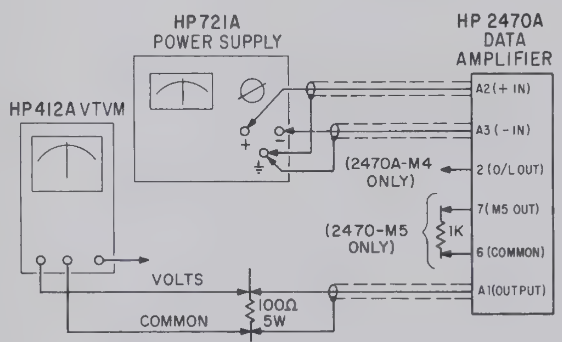
TABLE 4.3
IN-CABINET PERFORMANCE CHECKS

CHECK 1
OUTPUT(s)

The 2470A main output supplies ±10v across 100 ohms; it is self-limiting at ±(10.5 to 12.5)v across normal load and is not damaged by short circuit.

The 2470A-M4 also includes an O/L indicator and an overload signal. The no-overload state of the signal is -(17.5 to 19.5)v; the overload state, accompanied by lighting of the O/L indicator, is 0 to -1v.

The 2470A-M5 also includes a buffered second output that supplies ±10v across 1000 ohms and is not damaged by short circuit.



SETUP FOR OUTPUT CHECK

1. Make connections as shown above and turn on the 2470A and all test equipment.
2. Note time; checks 6, 7 and 8 are valid only after specified warmup of the 2470A, which must be timed.
3. Set VTVM to +30v range.
4. Set 2470A MULTIPLIER to 10 and vernier fully counterclockwise. Increase power supply output from 0 to 1v, noting that the VTVM reading increases to 10v. Enter result on the test card.
5. On 2470A with M5, check buffered output voltage across 1K load. Enter result on the test card.
6. Reverse 2470A +IN and -IN lead connections to power supply '+' and '-' terminals and set VTVM polarity to '-'.
7. Check main output voltage across 100 ohm load and enter result on the test card.
8. On 2470A with M5, check buffered output voltage across 1K load. Enter result on the test card.
9. Increase power supply output to 15 volts and enter VTVM reading on the test card.
10. On 2470A with M4, check O/L indicator and voltage on overload signal lead (with respect to A1 shield). Enter results on the test card.
11. Reverse 2470A +IN and -IN lead connections to power supply '+' and '-' terminals.
12. Check main output voltage across 100 ohm load and enter result on test card.
13. On 2470A with M4, reduce input voltage until O/L indicator extinguishes.
14. Check voltage on overload signal lead (from pin 2) as in step 10 and enter result on the test card.

NOTE

Short circuit protection is provided by passive circuit elements in the 2470A output circuit. Short circuit protection can be verified by shorting the main output, then the M5 output (2470A-M5 only), for an indefinite period with full scale input applied, and rechecking output(s) with short removed.

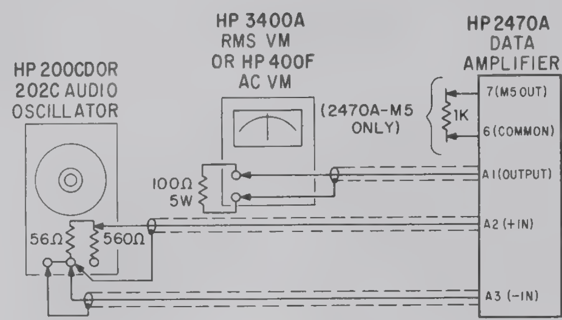
TABLE 4.3 (Cont'd)

CHECK 2

BANDWIDTH

The bandwidth of the 2470A main output extends from dc to 50Khz ±10% (the -3 db point) unless a more restricted bandwidth is requested.

The bandwidth of the 2470A-M5 buffered output may be equal to, or less than, the bandwidth of the main output.



SETUP FOR BANDWIDTH CHECK

1. Open the Amplifier case to determine if bandwidth of the main (or M5) output is other than 50 KHz. Enter 50 KHz or other bandwidth(s) here and on the test card. Then close the case.

   Main BW:__________ M5 BW:____________

2. Following check 1, make connections as shown above and turn on audio oscillator and AC VM.

3. Set 2470A MULTIPLIER to 10, 100 or 1000 and set vernier (on 2470A with M3) fully counterclockwise and locked there.

4. Set oscillator for frequency equal to 1/10 the main bandwidth and output that produces a 0 db reading on the AC VTVM set to 1v range.

5. Increase oscillator frequency until the AC VM reading is down to -3 db.

6. On the test card record the oscillator frequency setting. (It should be within 10% of the Main BW recorded in step 1.)

> NOTE
>
> The remaining steps apply only to 2470A with M5.

7. Set oscillator at the M5 BW figure recorded in step 1.

8. Set oscillator amplitude for 0 db reading on AC VM.

9. Connect M5 output to the AC VM in place of the main output. Increase or decrease frequency as needed to obtain -3 db reading.

10. Repeat step 8 with main output connected to the AC VM and step 9 until the M5 output is -3 db when the main output is 0 db.

11. On the test card record the oscillator frequency setting. (It should be within 10% of the M5 BW recorded in step 1.)

TABLE 4.3 (Cont'd)

CHECK 3

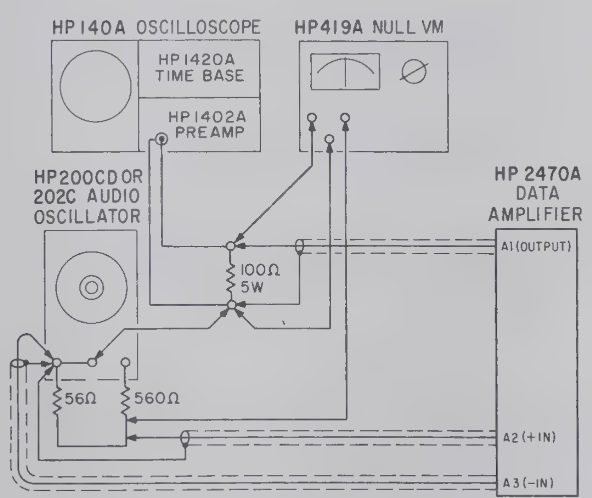
SLEWING RATE

The slewing rate specification in volts per second is the maximum rate of change of the output signal which the amplifier can deliver without introducing a dc offset that exceeds 0.1% of peak ac output, the slew limit threshold. The maximum slewing rate of a sine wave signal in volts per second is given by the following expression:

$$\text{sine wave}\left(\frac{dv}{dt}\right)_{max} = E_{pk}\,\omega = 2\sqrt{2}\pi\ E_{rms}\ F_{Hz},\ \text{or approx. } 8.9\ E_{rms}\ F_{Hz}$$

As the slewing rate required by the input is increased, amplifiers become progressively less able to keep up with changes of signal amplitude. A symmetrical input signal then starts to become unsymmetrical at the output, taking on an average value other than zero, a dc offset, which is the first indication of slew limiting.

For the 2470A, the start of slew limiting is defined as a dc offset at the output equal to 0.1% of the peak ac output (10 mv dc offset for 10 v peak ac output). The pre-amplifier slewing rate (rti rate) is faster than 10^6 volts per second and the basic 'post' amplifier slewing rate (rto rate) is faster than 10^7 volts per second, as defined in the specifications on page 1-4. However, with the filtering that is used to shape overall response of the 2470A, the slewing rate for an instrument with 50 Khz bandwidth is at least 3.5×10^6 volts per second at gain of 10 and at least 5×10^6 volts per second at gain of 100. Fast slewing assures that the 2470A delivers undistorted full-scale output throughout its complete bandwidth. At MULTIPLIER settings 10 through 1000, the 2470A will deliver full scale output beyond the high end (-3 db point) of its specified bandwidth without exceeding the previously-defined dc offset (0.1% of peak ac) that is the first indication of slew limiting. At gain of 1 with 2470A-M1 having 50 Khz bandwidth, slewing rate will be at least 10^6 volts per second, the rti rate, permitting ±10 v peak ac output to at least 16 Khz before slew limiting starts.



SETUP FOR SLEWING CHECK

1. Following check 2, connect setup as shown above and turn on the Oscilloscope and the null VM.

2. Zero the null VM and select its 10 mv range.

3. Set the 2470A MULTIPLIER to 10.

4. Set Oscilloscope to display channel A input at 2v/cm and '+' polarity. Set Time Base for automatic triggering from INT+ and 5μs/cm sweep. Adjust controls for sharp trace centered on the CRT.

5. Set oscillator for 50 Khz, 20v p-p output as displayed on the Oscilloscope.

6. While watching the dc offset reading on the null VM, increase the oscillator frequency, keeping the p-p amplitude on the Oscilloscope at 20v, until the offset just reaches 10 mv (0.1% of peak ac).

7. Record the oscillator frequency setting on the test card.

8. Repeat steps 6 and 7 with 2470A MULTIPLIER at 100. Record oscillator frequency on the test card.

TABLE 4.3 (Cont'd)

CHECK 3 (Cont'd)

NOTE

If desired, slewing rate along steepest part of the waveform can be checked directly with the Oscilloscope set to .5v/cm and .5μs/cm. In 2470A with 50Khz bandwidth, the trace should rise at least 7 cm (3.5v) in 2 cm (1μs) at gain of 10, representing 3.5×10^6 v/sec slewing rate. At gain of 100 the trace should rise at least 10 cm (5v) in 2 cm, representing 5×10^6 v/sec slewing rate.

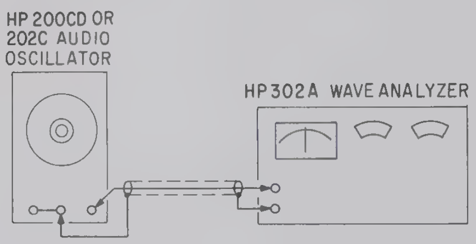
9. On 2470A with M1, set the MULTIPLIER to 1 and reduce oscillator frequency to point at which dc offset is 10 mv (0.1% of peak ac), while holding amplitude constant at 20v p-p, as displayed on the Oscilloscope (set for 2v/cm and 5μs/cm).

10. Record oscillator frequency on the test card.

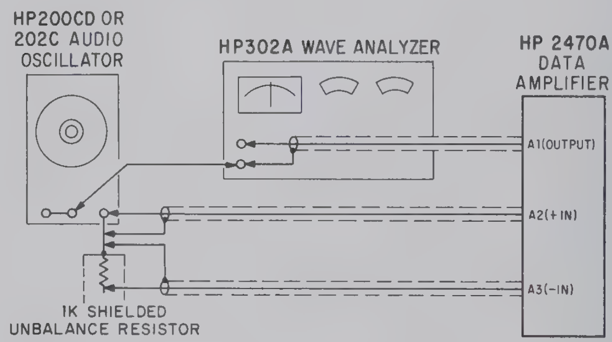
CHECK 4

COMMON MODE REJECTION

The common mode rejection of the 2470A for ac to 60 Hz is 120db (one million to one) at MULTIPLIER settings 30 through 1000. Rejection of 60 Hz commom mode is 110 db at gain of 10 and 90 db at gain of 1 (applicable only to 2470A-M1). Rejection of dc is 120 db at all MULTIPLIER settings.



CONN. FOR SETTING Ecm



SETUP FOR AC CMR CHECK

1. Following check 3, connect setup shown above and turn on Wave Analyzer.

2. Zero set Wave Analyzer carrier, then set it to 70 cps (70 Hz) frequency and normal mode.

3. Set the oscillator for 70 Hz, 7.7v rms output, tuned for peak on Wave Analyzer meter with Analyzer set to 10v rms range. Enter Analyzer meter reading on the test card.

4. Connect setup for AC CMR check.

5. Set Analyzer maximum input voltage to .03 and select 10mv range.

6. Set 2470A MULTIPLIER to 1000 and vernier (on 2470A with M3) fully counterclockwise and locked there.

7. Record the reading of the Analyzer meter on the test card. (Reading should not exceed 7.7 mv, which is 7.7μv rti times gain of 1000.

8. Interchange +IN and -IN lead connections to shielded unbalance resistor without changing shield connection and record reading of the Analyzer meter on the test card.

9. Repeat steps 7 and 8, but at gain of 300, on Analyzer 3mv range. Enter results on the test card.

10. Repeat steps 7 and 8, but at gain of 100, on Analyzer 1 mv range. Enter results on the test card.

TABLE 4.3 (Cont'd)

CHECK 4 (Cont'd)

11. Repeat steps 7 and 8, but at gain of 30, on Analyzer 300 μv range. Enter results on the test card.

12. Repeat steps 7 and 8, but at gain of 10, on Analyzer 300 μv range. Enter results on the test card.

13. When checking 2470A-M1, repeat steps 7 and 8, but at gain of 1, on Analyzer 300 μv range. Enter results on the test card.

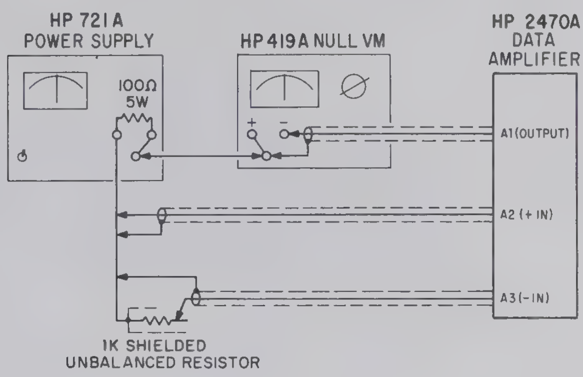
14. Connect DC CMR check setup and turn on power supply and set it for 10v output limited to 225 ma current. Record the 10v common mode voltage on the test card.

15. Zero the null VM and set it to 30 mv range.

16. Set the 2470A MULTIPLIER to 1000.

17. Switch power supply off and on to determine common mode output for 10v dc common mode input (difference between null VM readings). Record the result on the test card.

18. Interchange +IN and -IN lead connections to shielded unbalance resistor without changing shield connections and switch power supply off and on to determine common mode output. Enter result on the test card.



SETUP FOR DC CMR CHECK

19. Repeat steps 17 and 18, but at gain of 100, on null VM 3 mv range. Enter results on the test card.

20. Repeat steps 17 and 18, but at gain of 10, on null VM 300μv range. Enter results on the test card.

21. When checking 2470A-M1, repeat steps 17 and 18, but at gain of 1, on null VM 100μv range. Enter results on the test card.

TABLE 4.3 (Cont'd)

CHECK 5
NOISE

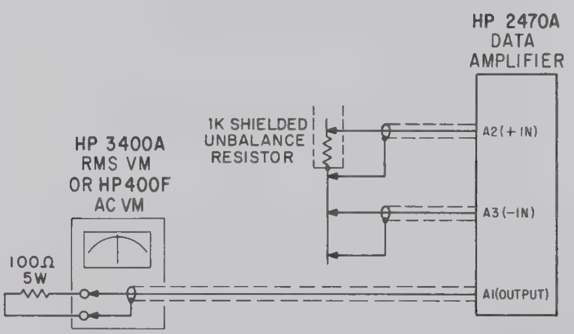
The noise in the output of the 2470A is dependent upon the bandwidth of your instrument and the gain setting. Noise referred to the input times gain adds in rms fashion to noise referred to the output. Noise at various bandwidths at gains of 10, 100, and 1000 is listed below. If the bandwidth of your instrument is between two of the bandwidths listed, its maximum noise can be determined by the following calculation:

$$e_{n(x)} = \sqrt{\frac{BW(x)}{BW(ref)}} \text{ times } e_{n(ref)}$$

For BW(ref) use BW nearest (factorially) to BW(x). For example, if BW(x) is 50 Hz, use 100 Hz as BW(ref). Then:

$$e_{n(x)} = \sqrt{\frac{1}{2}} \text{ times noise with 100 Hz (ref) bandwidth}$$

		Maximum Output Noise at		
Bandwidth	Basic Noise Specification	Gain = 10	Gain = 100	Gain = 1000
0 - 50 Khz	5μv x gain & 500μv (rms)	500μv rms	710μv rms	5mv rms
0 - 10 Khz	3μv x gain & 300μv (rms)	300μv rms	420μv rms	3mv rms
0 - 1 Khz	1μv x gain & 30μv (rms)	32μv rms	100μv rms	1mv rms
0 - 100 Hz	3μv x gain & 30μv (p-p)	42μv p-p	420μv p-p	3mv p-p
0 - 10 Hz	1μv x gain & 10μv (p-p)	14μv p-p	100μv p-p	1mv p-p



SETUP FOR NOISE CHECK

1. Following check 4, make connections as shown above.

   NOTE: If bandwidth of your 2470A is less than 1 KHz, use HP-140A oscilloscope with HP-1403A plug-in (instead of AC VM) for noise check. Complete connections through the binding post adapter furnished with the 1403A. Connect the 2470A output shield to the '-', GUARD, and GND terminals and the output to the '+' terminal of the adapter.

2. From the tabulation above, or by calculation, determine maximum permissible noise for your 2470A at gains of 10, 100, and 1000.

3. Enter the values determined in step 2 on the test card as the Specification Limits for steps 4, 5, and 6 of this check. (For a 2470A with 50 Khz bandwidth, you should enter 500 μv, 710 μv, and 5 mv for steps 4, 5, and 6, respectively).

4. With the 2470A MULTIPLIER at 10, set the AC VM or the HP-1403A Amplifier for the most sensitive range that gives an on-scale reading. Measure actual noise and enter the result on the test card.

5. Repeat step 4 at gain of 100.

6. Repeat step 4 at gain of 1000.

   NOTE: If noise exceeds the specified maximum, especially at gain of 1000, verify that connections are secure and making good contact (and that the unbalance resistor has not opened), and repeat steps 4, 5, and 6 before assuming failure of the noise check.

TABLE 4.3 (Cont'd)

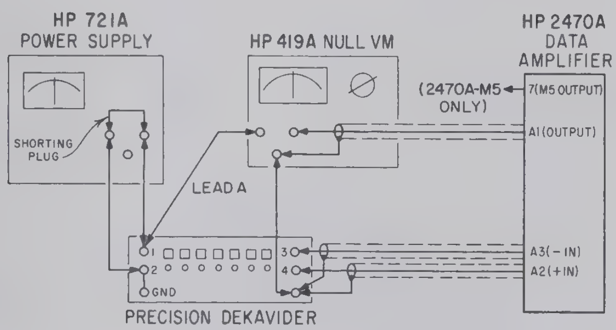
CHECK 6

GAIN ACCURACY

The fixed gain settings of the standard 2470A are 10, 30, 100, 300, and 1000; the fixed settings of the 2470A-M1 are 1, 10, 100, and 1000. Accuracy of any gain can be set to .01% of reading (the resolution of the gain TRIM adjustment); usually gain of 10 is the calibrated setting. Gain-to-gain accuracy is .02% of reading.

The 2470A-M3 is equipped with a vernier which can be used to multiply the fixed gains as much as 3.5. Accuracy of dial-set gains is ±3%.

Gain of the 2470A-M5 buffered output is initially x1 ±.01% with respect to the main output.



SETUP FOR GAIN ACCURACY CHECK

1. Following check 5, and after the 2470A has been given full warmup (1-1/2 hours in free air or 30 minutes in the Combining Case), make connections as shown above.

2. Set the Dekavider to 0000000. Then zero the null VM and set it to 10 mv range.

3. Set 2470A MULTIPLIER to 1000 and set vernier (on 2470A-M3) fully counterclockwise and lock it there.

4. With screwdriver, set 2470A ZERO for minimum reading (less than ±2mv) on the null VM (less than 2μv referred to the input).

5. Record zero set time and date on the test card; this will be used to determine when to check zero drift per day (after 8 hours).

6. Set 2470A MULTIPLIER to 10; disconnect the shorting plug. Then turn on the power supply, and set it for 10v output (indicated on its panel meter).

7. With screwdriver, set GAIN for minimum reading (less than ±1 mv) on the null VM. Record the null VM reading on the test card.

8. Turn off power supply and connect shorting plug between its '+' and '-' terminals.

9. Set Dekavider to 0333333 and 2470A MULTIPLIER to 30.

10. Note zero reading on null VM, then disconnect shorting plug and turn on power supply. Note new null VM reading and enter difference between readings (including polarity) on the test card.

11. Repeat the routine of steps 8 through 10 at the following settings:

Dekavider	Multiplier
0100000	100
0033333	300
0010000	1000
999999TEN*	1*

*2470A-M1 only

12. On 2470A-M3, repeat the routine of steps 8 through 10, with MULTIPLIER at 10, the null VM set to 300 mv range, at the following settings:

Dekavider	Vernier	Gain
0500000	4.00	20
0285714	10.00	35

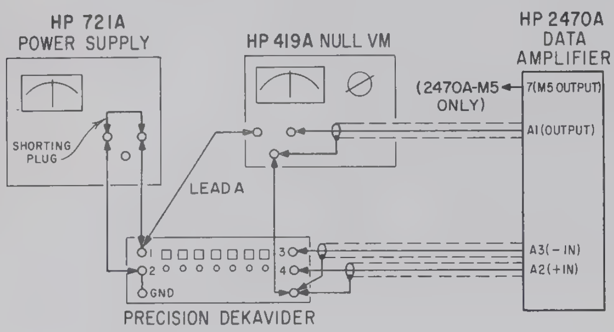
13. On 2470A-M5 connect M5 output lead (from pin 7 of rear connector) to null VM '+' terminal. Then disconnect lead 'A' from null VM and Dekavider. Set 2470A MULTIPLIER to 10, vernier (of 2470A-M3, M5) fully counterclockwise and Dekavider to 1000000. Record null VM reading (10 mv range) on the test card.

TABLE 4.3 (Cont'd)

CHECK 7
LINEARITY

Linearity of the 2470A is ±.002% of full scale (±.2 mv) for both input polarities.

Linearity of the M5 output of 2470A-M5 instruments is ±.02% of full scale (±2 mv) with respect to the main output.



SETUP FOR LINEARITY CHECK

Power Supply Output	% of Step 3 Figure
2v (20% fs)	20%
3v (30% fs)	30%
4v (40% fs)	40%
5v (50% fs)	50%
6v (60% fs)	60%
7v (70% fs)	70%
8v (80% fs)	80%
9v (90% fs)	90%

1. Following check 6, connect setup as shown above.

2. Set the Dekavider to 1000000. Then zero the null VM and set it to 1 mv range.

3. On the test card, enter the measurement result obtained in step 7 of check 6.

4. Turn off Power Supply, connect shorting plug across the Power Supply '+' and '-' terminals, and record the null VM reading on the test card.

5. Disconnect the shorting plug and set the Power Supply for 1v output

6. Observing polarities, subtract the figure recorded in step 4 and 10% of the figure recorded in step 3 from the null VM reading, and enter the result on the test card.

   EXAMPLE: If the step 4 figure is +.09 mv and the step 3 figure is -.5 mv, subtract +.04 mv (+.09 mv +10% of .5 mv) from the null VM reading. If the null VM reading is +.2 mv, enter +.16 mv (+.2 mv -.04 mv) on the test card; for a -.12 mv reading, enter -.16 mv (-.12 mv - .04 mv) on the test card.

7. Repeat step 6 at the following Power Supply output voltages, subtracting corresponding percentages of the step 3 figure. Enter results on the test card.

8. Turn off the Power Supply, reverse connections to its '+' and '-' terminals, and connect the shorting plug between the '+' and '-' terminals. Then record the null VM reading on the test card.

9. Disconnect the shorting plug, turn on the Power Supply, and set the Power Supply for 1v output.

10. Observing polarities, subtract the figure recorded in step 8 and 10% of the figure recorded in step 3 from the null VM reading and enter the result on the test card.

11. Repeat step 10 at 10% increments of Power Supply output voltage as in step 7, subtracting corresponding percentages of the step 3 figure. Enter results on the test card.

12. On 2470A-M5, connect M5 output lead (from pin 7 of rear connector) to null VM '+' terminal. Then disconnect lead A from null VM and Dekavider.

13. Set the null VM to 3 mv range and the Power Supply for 10v output. Record null VM reading on the test card.

14. Repeat step 4 to determine M5 zero output with respect to main output. Enter null VM reading on the test card. Then repeat step 5.

TABLE 4.3 (Cont'd)

CHECK 7 (Cont'd)

15. Observing polarities, subtract the figure recorded in step 14 and 10% of the figure recorded in step 13 from the null VM reading; enter the result on the test card.

16. Repeat step 15 at 10% increments of Power Supply output voltage as in step 7, subtracting corresponding percentages of the step 13 figure. Enter results on the test card.

17. Turn off the Power Supply, reverse connections to its '+' and '-' terminals, and connect the shorting plug between the '+' and '-' terminals. Then record the null VM reading on the test card.

18. Disconnect the shorting plug, turn on the Power Supply, and set the Power Supply for 10v output. Record null VM reading on the test card. Then set the Power Supply for 1v output.

19. Observing polarities, subtract the figure recorded in step 17 and 10% of the figure recorded in step 18 from the null VM reading; enter the result on the test card.

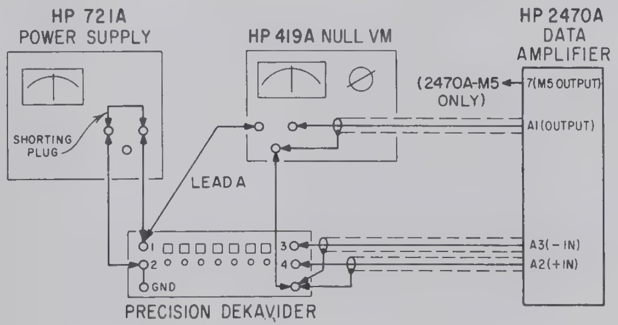
20. Repeat step 19 at 10% increments of Power Supply output voltage as in step 7, subtracting corresponding percentages of the step 18 figure. Enter results on the test card.

CHECK 8
ZERO DRIFT PER DAY

8-hour zero drift of the 2470A is no more than ±5 μv times gain ±50 μv, assuming constant temperature.

Full vernier multiplication with the 2470A-M3 adds no more than ±75 μv offset to the output, assuming constant temperature.

8-hour zero drift of the M5 output of 2470A-M5 is no more than ±50 μv with respect to the main output, assuming constant temperature.



SETUP FOR ZERO DRIFT CHECK

1. Following check 7, and after the 2470A has operated 8 hours since zeroing in step 5 of check 6, connect setup as shown above.

2. Set the Dekavider to 0000000 and zero the null VM and set it to 10 mv range.

3. Set 2470A MULTIPLIER to 1000 and set vernier (on 2470A-M3) fully counterclockwise and lock it there.

4. Record null VM reading on the test card.

5. Set 2470A MULTIPLIER to 100 and record null VM (1 mv range) reading on the test card.

6. Set 2470A MULTIPLIER to 10 and record null VM reading on the test card.

7. On 2470A-M3, set vernier fully clockwise and record null VM reading on the test card.

8. On 2470A-M5, connect M5 output lead (from pin 7 of rear panel connector) to null VM '+'. Then disconnect lead A from null VM and Dekavider and record null VM reading on the test card.

TABLE 4.3 (Cont'd)

CHECK 9

SETTLING AND OVERLOAD RECOVERY

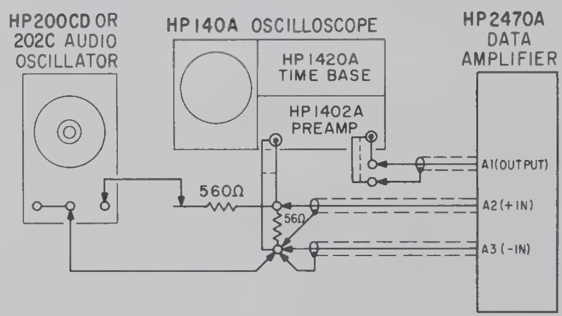
The 2470A with 50 KHz bandwidth settles to .01% of final value in 100 μs.

Recovery from 10x full scale overload requires only 100 μs plus settling time, provided the input does not exceed ±10v.

NOTE

Because the 2470A is a direct-coupled amplifier, verification of bandwidth (in check 2) and gain accuracy (in check 6) implies 100 μs settling time to .01% of final value. No direct check is necessary.

Since this is true, overload recovery time can be verified by a simple output signal zero crossing check that demonstrates the amplifier's recovery to its linear operating region. (In this region, the settling time specification applies). The deviation of the output signal from symmetry with a symmetrical 10x full scale sine wave input signal, is a measure of the time required for overload recovery.



SETUP FOR OVERLOAD RECOVERY CHECK

1. Following check 8, connect setup as shown above.

2. Set audio oscillator for 200 mv p-p, 10 KHz signal on Oscilloscope channel A (Oscilloscope ch A set for 20 mv/cm, time base set for 10 μs sweep time).

3. Set 2470A MULTIPLIER to 1000.

4. On Oscilloscope channel B, display one complete output waveform at 5v/cm, using dc input with trace centered.

5. Record positive and negative clipping levels and symmetry ratio on the test card.

EXAMPLE: If one half-cycle of the output waveform has 450 μs duration and the other half-cycle has 550 μs duration, the symmetry is 55-45, which is 'better' than 60-40.

NOTE

If a suitable audio oscillator (such as the HP-205AG) is available, recovery from ±20v peak overload can be checked. With 40v p-p 100 Hz input to the 2470A at gain of 1000, the symmetry of the output signal should be 70-30 or better (Oscilloscope sweep time set to 1 ms/cm).

TABLE 4.3 (Cont'd)

CHECK 10

TEMPERATURE COEFFICIENTS

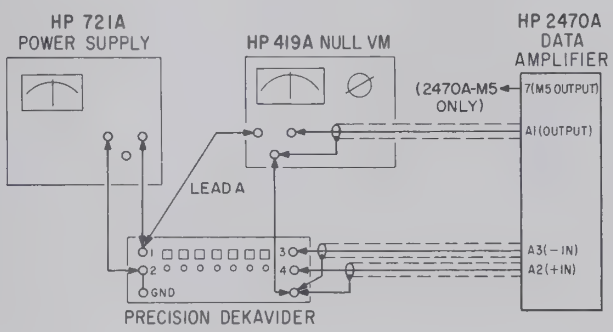
The 2470A temperature coefficients are:

Zero drift: $<\pm 1\ \mu v \pm .5$ namp rti $\pm 10\mu v$ rto per °C.

Gain Temperature Coefficient: ±.001% per °C (±.002% per °C for 2470A-M3).

NOTE

This procedure is provided to assist incoming inspection testing of the 2470A. A temperature chamber is required that is capable of holding the 2470A in a Combining Case at 0°C, 25°C, and 55°C temperatures for three hours.



SETUP FOR TEMP. COEFF. CHECKS

1. Install the 2470A in a Combining Case with all spaces filled by instruments, or by HP-12504A Blank Panels.

2. Install the Combining Case in a temperature chamber so that power and signal leads run outside of the chamber and connect to test equipment as indicated in the setup shown avove.

3. Turn on the 2470A and set the MULTIPLIER to 1000 and the vernier (of 2470A-M3) fully counter-clockwise.

4. Set the Dekavider to 0030000, turn on all test equipment, and set the Power Supply for 10v output, as indicated on its panel meter. Set the temperature chamber to 25°C and close it.

5. After the 2470A has been operating 30 minutes at 25°C, open the temperature chamber and set the ZERO (screwdriver) adjustment for minimum reading (less than ±2 mv) on the null VM 10 mv range. Record zero offset (including polarity) on the test card.

6. Set the 2470A MULTIPLIER to 10 and the Dekavider to 1000000. Then set the GAIN (screwdriver) adjustment for minimum reading (less than ±1 mv) on the null VM. Record gain accuracy reading (including polarity) on the test card.

7. Close the temperature chamber and set it for 0°C. Set the null VM to 30 mv range.

8. After the 2470A has been operating 2-1/2 hours in the chamber at 0°C, open the chamber and check zero offset with Dekavider set to 0030000 and 2470A MULTIPLIER at 1000.

9. Check gain accuracy with 2470A MULTIPLIER at 10 and the Dekavider set to 1000000. Record the null VM reading on the test card.

10. Set the temperature chamber to 25°C, the 2470A MULTIPLIER to 1000, and the Dekavider to 0030000. After the 2470A has been operating 2-1/2 hours at 25°C, repeat steps 5 and 6.

11. Set the temperature chamber to 55°C and set the null VM to 100 mv range.

12. After the 2470A has been operating 3 hours in the chamber at 55°C, open the chamber and check zero offset as in step 8. Record null VM reading on the test card.

13. Check gain accuracy as in step 9. Record the null VM reading on the test card.

NOTE: Allow 3 hours for the 2470A to cool to room temperature (assumed to be 25°C) before starting the next performance check or before calibrating it for operation.

TABLE 4.3 (Cont'd)

CHECK 11

LONG-TERM ZERO AND GAIN STABILITY

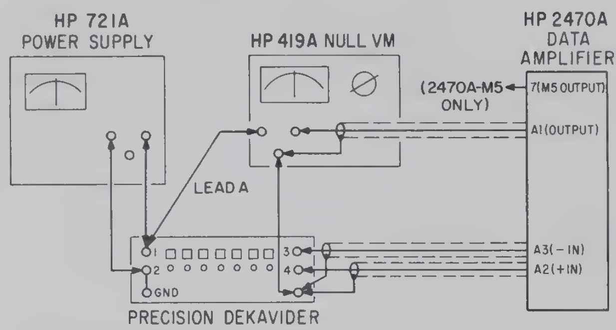
Monthly stability figures of the 2470A are:

Zero drift: ±25 μv rti ±250 μv rto*
Gain stability: ±.005% *

* Assuming constant temperature.

NOTE

This procedure is provided primarily to assist incoming inspection testing of the 2470A; its use in a scheduled performance check preventive maintenance program is not recommended.



SETUP FOR LONG-TERM STABILITY CHECKS

1. Connect setup shown above, turn on the 2470A and all test equipment, and wait 1-1/2 hours for the 2470A to warm up in free air or 30 minutes for the 2470A to warm up in the Combining Case.

2. Set the Dekavider to 0000000. Set Power Supply for 10v output. Zero the null VM and set it to 10 mv range.

3. Set 2470A MULTIPLIER to 1000 and set vernier (on 2470A-M3) fully counterclockwise and lock it there.

4. With screwdriver, set 2470A ZERO for minimum reading (less than ±2 mv) on the null VM. Record zero offset reading on the test card.

5. Set 2470A MULTIPLIER to 10, set the Dekavider to 1000000, and set 2470A GAIN for minimum reading (less than ±1mv) on the null VM. Record gain accuracy reading on the test card.

6. Record the date on the test card.

7. Return the 2470A to normal service for 30 days, but with the ZERO and GAIN adjustments sealed to prevent recalibration during that period.

8. At the end of 30 days, repeat steps 1 through 5, recording the null VM zero offset reading (use 30 mv range if necessary) on the test card before re-zeroing and recording the gain accuracy reading on the test card before resetting the GAIN.

9. Subtract the step 4 zero offset reading from the step 8 zero offset reading and record the result on the test card.

10. Subtract the step 5 gain accuracy reading from the step 8 gain accuracy reading and record the result on the test card.

PERFORMANCE CHECK TEST CARD

FOR

HP-2470A DATA AMPLIFIER

Serial No. ____________ Date ____________

Step	Item(s) Checked	Measurement Result	Specification Limit (s)	Is Result Acceptable?
CHECK 1 - OUTPUTS(s)				
4	Positive Output, 100Ω load	____	+10v dc	____
5	Positive M5 Output, 1K load	____	+10v dc	____
7	Negative Output, 100Ω load	____	-10v dc	____
8	Negative M5 Output, 1K load	____	-10v dc	____
9	Max. Neg. Output, 100Ω load	____	-(10. 5 to 12. 5)v dc	____
10	M4 O/L Indicator	____	lighted	____
	M4 Overload signal voltage	____	0 to -1v	____
12	Max. Pos. Output, 100Ω load	____	+(10. 5 to 12. 5)v dc	____
14	M4 Overload signal voltage	____	-(17. 5 to 19. 5)v dc	____
CHECK 2 - BANDWIDTH				
1	Main BW (on decal)	____	Not Applicable	Not Applicable
	M5 BW (on decal)	____	Not Applicable	Not Applicable
6	Main BW (measured)	____	Step 1 Main BW ±10%	____
11	M5 BW (measured)	____	Step 1 M5 BW ±10%	____
CHECK 3 - SLEWING RATE				
7	Frequency for dc offset equal to 0. 1% of peak ac at gain of 10.	____	> 50 KHz (or Main BW)	____
8	Frequency for dc offset equal to 0. 1% of peak ac at gain of 100.	____	> 50 KHz (or Main BW)	____
10	Frequency for dc offset equal to 0. 1% of peak ac at gain of 1 (2470A-M1 only)	____	> 16 KHz (or 1/3 Main BW)	____

PERFORMANCE CHECK TEST CARD

FOR

HP-2470A DATA AMPLIFIER

Serial No. ______________ Date ______________

Step	Item(s) Checked	Measurement Result	Specification Limit (s)	Is Result Acceptable?
CHECK 4 - COMMON MODE REJECTION				
3	70 Hz Common Mode Signal	______	7.7v rms amplitude	Not Applicable
7	CM Output at gain of 1000, -IN unbalance	______	< 7.7 mv rms	______
8	CM Output at gain of 1000, +IN unbalance	______	< 7.7 mv rms	______
9	CM Output of gain of 300, +IN unbalance	______	< 2.3v rms	______
	CM Output at gain of 300, -IN unbalance	______	< 2.3v rms	______
10	CM Output at gain of 100, -IN unbalance	______	< 0.77 mv rms	______
	CM Output at gain of 100, +IN unbalance	______	< 0.77 mv rms	______
11	CM Output at gain of 30, +IN unbalance	______	< 230 μv rms	______
	CM Output at gain of 30, -IN unbalance	______	< 230 μv rms	______
12	CM Output at gain of 10, -IN unbalance	______	< 243 μv rms	______
	CM Output at gain of 10, +IN unbalance	______	< 243 μv rms	______
13	CM Output at gain of 1 (2470A-M1), +IN unbalance	______	< 243 μv rms	______
	CM Output at gain of 1 (2470A-M1), -IN unbalance	______	< 243 μv rms	______
14	DC Common Mode Signal	______	10v dc	Not Applicable
17	CM Output at gain of 1000, -IN unbalance	______	< 10 mv	______
18	CM Output at gain of 1000, +IN unbalance	______	< 10 mv	______
19	CM Output at gain of 100, +IN unbalance	______	< 1 mv	______
	CM Output at gain of 100, -IN unbalance	______	< 1 mv	______
20	CM Output at gain of 10, -IN unbalance	______	< 100 μv	______
	CM Output at gain of 10, +IN unbalance	______	< 100 μv	______
21	CM Output at gain of 1 (2470A-M1), +IN unbalance	______	< 10 μv	______
	CM Output at gain of 1 (2470A-M1), -IN unbalance	______	< 10 μv	______

PERFORMANCE CHECK TEST CARD

FOR

HP-2470A DATA AMPLIFIER

Serial No. ______________ Date ______________

Step	Item(s) Checked	Measurement Result	Specification Limit (s)	Is Result Acceptable?
CHECK 5 - NOISE				
4	Noise output at gain = 10			
5	Noise output at gain = 100			
6	Noise output at gain = 1000			
CHECK 6 - GAIN ACCURACY				
5	Zero set time and date		Not Applicable	Not Applicable
7	Accuracy at Gain = 10		< ±1 mv (< ±.01% of 10v)	
10	Accuracy at Gain = 30		< ±2 mv ±step 7 reading	
11	Accuracy at: Gain = 100		< ±2 mv ±step 7 reading	
	Gain = 300		< ±2 mv ±step 7 reading	
	Gain = 1000		< ±2 mv ±step 7 reading	
	Gain = 1		< ±2 mv ±step 7 reading	
12	Accuracy at: Gain = 20		< ±300 mv (< ±3% of 10v)	
	Gain = 35		< ±300 mv (< ±3% of 10v)	
13	Accuracy of M5 output with respect to Main output		< ±1 mv (< ±.01% of 10v)	
CHECK 7 - LINEARITY				
3	Accuracy at Gain = 10		< ±1 mv (< ±.01% of 10v)	
4	'-' Zero at Gain = 10		< ±.1 mv (< ±.2 mv in free air)	
6	Linearity at -1v (-10% fs)		< ±.2 mv (< ±.002% fs)	
7	Linearity at: -2v (-20% fs)		< ±.2 mv	
	-3v (-30% fs)		< ±.2 mv	
	-4v (-40% fs)		< ±.2 mv	
	-5v (-50% fs)		< ±.2 mv (< ±.002% fs)	
	-6v (-60% fs)		< ±.2 mv	
	-7v (-70% fs)		< ±.2 mv	
	-8v (-80% fs)		< ±.2 mv	
	-9v (-90% fs)		< ±.2 mv	
8	'+' Zero at Gain = 10		< ±.1 mv (< ±.2 mv in free air)	
10	Linearity at +1v (+10% fs)		< ±.2 mv (< ±.002% fs)	

PERFORMANCE CHECK TEST CARD

FOR

HP-2470A DATA AMPLIFIER

Serial No. ______________ Date ______________

Step	Item(s) Checked	Measurement Result	Specification Limit (s)	Is Result Acceptable?
CHECK 7 - LINEARITY (Cont'd)				
11	Linearity at: +2v (+20% fs)		< ±.2 mv	
	+3v (+30% fs)		< ±.2 mv	
	+4v (+40% fs)		< ±.2 mv	
	+5v (+50% fs)		< ±.2 mv (< ±.002% fs)	
	+6v (+60% fs)		< ±.2 mv	
	+7v (+70% fs)		< ±.2 mv	
	+8v (+80% fs)		< ±.2 mv	
	+9v (+90% fs)		< ±.2 mv	
13	M5 Accuracy (+100% fs)		< ±1 mv (< ±.01% of 10v)	
14	M5 Zero (+ connection)		< ±.5 mv (< ±.005% fs)	
15	M5 Linearity at +1v (+10% fs)		< ±2 mv (< ±.02% fs)	
16	M5 Linearity at: +2v (+20% fs)		< ±2 mv	
	+3v (+30% fs)		< ±2 mv	
	+4v (+40% fs)		< ±2 mv	
	+5v (+50% fs)		< ±2 mv (< ±.02% fs)	
	+6v (+60% fs)		< ±2 mv	
	+7v (+70% fs)		< ±2 mv	
	+8v (+80% fs)		< ±2 mv	
	+9v (+90% fs)		< ±2 mv	
17	M5 Zero (- connection)		< ±.5 mv (< ±.005% fs)	
18	M5 Accuracy (-100% fs)		< ±1 mv (< ±.01% of 10v)	
19	M5 Linearity at -1v (-10% fs)		< ±2 mv (< ±.02% fs)	
20	M5 Linearity at: -2v (-20% fs)		< ±2 mv	
	-3v (-20% fs)		< ±2 mv	
	-4v (-40% fs)		< ±2 mv	
	-5v (-50% fs)		< ±2 mv (< ±.02% fs)	
	-6v (-60% fs)		< ±2 mv	
	-7v (-70% fs)		< ±2 mv	
	-8v (-80% fs)		< ±2 mv	
	-9v (-90% fs)		< ±2 mv	

PERFORMANCE CHECK TEST CARD

FOR

HP-2470A DATA AMPLIFIER

Serial No. ________________ Date ________________

Step	Item(s) Checked	Measurement Result	Specification Limit(s)	Is Result Acceptable?
CHECK 8 - ZERO DRIFT PER DAY AT CONSTANT AMBIENT TEMPERATURE				
4	Zero offset at gain = 1000	____________	< ±5.1 mv (< ±15.1 mv in free air)	____________
5	Zero offset at gain = 100	____________	< ±.55 mv (< ±1.55 mv in free air)	____________
6	Zero offset at gain = 10	____________	< ±.1 mv (< ±.2 mv in free air)	____________
7	Zero offset of 2470A-M3 at gain = 35 (with VERNIER fully clockwise)	____________	< ±.18 mv (< ±.28 mv in free air)	____________
8	Zero offset of M5 Output	____________	< ±.5 mv	____________
CHECK 9 - SETTLING AND OVERLOAD RECOVERY				
5	Positive clipping level	____________	+(10.5 to 12.5)v	____________
	Negative clipping level	____________	-(10.5 to 12.5)v	____________
	Symmetry	____________	60-40 or better	____________
CHECK 10 - TEMPERATURE COEFFICIENTS				
5	Initial zero offset at 25°C	____________	< ±2 mv	____________
6	Initial gain accuracy at 25°C	____________	< ±1 mv	____________
8	Zero offset at 0°C	____________	< ±43.8 mv* ±step 5 result	____________
9	Gain accuracy at 0°C	____________	< ±2.5 mv** ±step 6 result	____________
10	2nd zero offset at 25°C	____________	< ±2 mv	____________
	2nd gain accuracy at 25°C	____________	< ±1 mv	____________
12	Zero offset at 55°C	____________	< ±50.3 mv*±step 10 result	____________
13	Gain accuracy at 55°C	____________	< ±3 mv** ±step 10 result	____________
			*Including 5.05 mv normal zero drift.	
			**With 2470A-M3, add ±5 mv and ±6 mv to limits	
CHECK 11 - LONG-TERM ZERO DRIFT AND GAIN STABILITY				
4	Initial zero offset reading	____________	< ±2 mv	____________
5	Initial gain accuracy reading	____________	< ±1 mv	____________
6	Date	____________	Not Applicable	Not Applicable
8	Zero offset after 30 days	____________	< ±25.3 mv* ±step 4 result	____________
	Gain accuracy after 30 days	____________	< ±.5 mv ±step 5 result	____________
9	30 day zero drift	____________	< ±25.3* mv	____________
10	30 day gain stability	____________	< ±.5 mv (< ±.005% of 10v)	____________

*< ±35.3 mv in free air

4.3 ACCESS TO INTERNAL ADJUSTMENTS AND COMPONENTS

For access to adjustments and components inside of the 2470A, release the plastic cross straps at the top and open the case. All internal adjustments are now accessible.

For access to test points and components on the Preamplifier circuit board. remove the three cover shield attaching screws and lift off the cover shield.

For replacement of components on either circuit board, the eight snap fasteners attaching the board to the case must be snapped out. If board removal is required, pliers may have to be used, gently but firmly, to remove snap fasteners that fit too snugly to be removed by the fingers alone.

Access for replacement of parts on the front or rear panel is provided by sliding the panel upward out of the section of case in which it is installed. The inside view of the rear panel in Figure 5.2 (page 5-5) shows it partly removed in this manner.

Reassembly of the 2470A after all internal maintenance has been accomplished is essentially the reverse of the procedure used to gain access. Slide the front or rear panel down into place on the dowel rods that are integral with the case. Line up the printed circuit board with the holes molded in the case and snap in the plastic fasteners. Replace the Preamplifier cover shield and secure it with the attaching screws; be sure to install the nylon screw in the rear-most hole, as marked on the cover shield. Close the case and secure the cross-straps.

4.4 TROUBLESHOOTING

4.4.1 System Troubleshooting.

The 2470A is a highly-reliable Data Amplifier that is designed for a predicted* MTBF (mean time betwen failures) of 20,000 hours (more than two years of continuous operation) at 25°C ambient. It should give little if any trouble for several years. Troubles of the system are generally traceable to open-circuiting of the input leads, the signal source, or the common mode return, not to trouble in the 2470A.

*Using component-count technique

In multi-channel data systems with one channel apparently faulty and others performing correctly, the simplest method of system troubleshooting is as follows:

1. Remove the suspected 2470A and check fuse, correct setting of the LINE VOLTAGE switch, and make certain the POWER switch is ON.

2. Interchange the suspected 2470A with one known to be operating correctly; make certain that their control settings agree.

3. If trouble does not move with the suspected 2470A, look for bad connections to the signal source, open-circuited signal source, open-circuited common mode return, or incorrectly set controls. The installation and operation instructions presented in section 2 of this handbook must be followed faithfully to achieve correct performance of the 2470A.

4. If trouble does move with the suspected 2470A, it should be checked according to the instructions in paragraphs 4.4.2 through 4.4.4.

4.4.2 2470A Troubles

The principal troubles that may be encountered in the 2470A are summarized below, with suggested causes of the trouble. Assembly numbers A1, A2, and A3 identify components on the MULTIPLIER switch assembly, the Preamplifier assembly, and the 'Post' amplifier assembly, respectively. The theory of operation in section 3, schematics and parts location illustrations in section 5, and additional instructions in paragraphs 4.4.3 and 4.4.4 are provided to assist isolation of these troubles.

- High Positive or Negative Output — no response to input:

  Either input lead broken inside of the 2470A.

  Open feedback connection from 'Post' amplifier output to input.

  Defective transistor or resistor on Preamplifier or 'Post' amplifier.

- Amplifier Oscillating:

  Open or shorted capacitor or open resistor in one of the gain-bandwidth feedback networks discussed in Section 3.

- Noisy Output:

  Noisy Preamplifier or 'Post' amplifier input transistor, or faulty capacitor or resistor in one of the gain-bandwidth feedback networks discussed in Section 3.

- Output Low — no response to input:

  Rg connection through MULTIPLIER switch assembly open.

  Thermal switch S4 (attached to T1) open, possibly because of overheating of T1 (look for shorted T1 or shorted A2 or A3 power supply circuits).

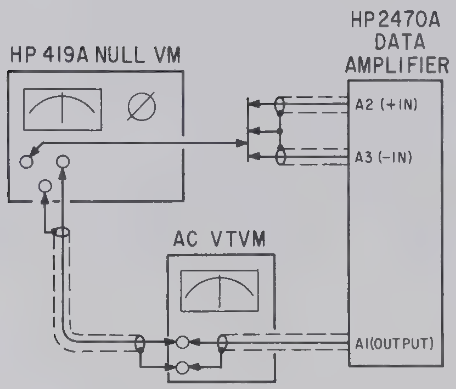
  A2- C17 shorted.

  A3- C4 (or C26) shorted.

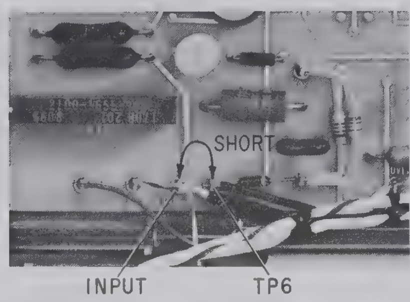
4.4.3 Isolation of Trouble to A2 or A3

Troubles such as high output, amplifier oscillation, and noisy output can be isolated to A2 or A3 as follows:

1. Establish initial troubleshooting setup as specified in Figure 4.1 (2470A connected through 12503A Cable Assembly) and turn on the 2470A and all test equipment.



A. COMPLETE CONNECTIONS SHOWN



B. ON 'POST' AMP, SHORT INPUT TO TP6

INITIAL TROUBLESHOOTING SETUP
FIGURE 4.1

2. Set AC VTVM and the Null VM to 30v range and the 2470A MULTIPLIER to 1000. Switch the meters down-range to obtain reading in the upper 2/3 of the scale.

3. AC readings significantly greater than 1 mv or dc readings greater than 100 mv indicate trouble in 'Post' amplifier assembly A3. DC readings up to 100 mv probably result from incorrect setting of the internal zero adjustment of the 'Post' amplifier. (See paragraph 4.7.2 for adjustment procedure.) DC or ac readings less than 1 mv indicate trouble is probably not in A3.

4. If step 3 readings are less than 1 mv, reset the meters to 30v range and disconnect the 'Post' amplifier input short.

5. Switch the meters down range to obtain readings in the upper 2/3 of the scale. An ac reading significantly greater than 5 mv indicates trouble in Preamplifier assembly A2. A dc reading significantly greater than 5 mv may indicate incorrect zeroing (see NOTE below), or trouble in A2.

NOTE

With the 2470A at gain of 1000, dc readings up to 200 mv can result from incorrect setting of the front panel ZERO adjustment – dc readings up to 9v can result from incorrect setting of the Preamplifier internal zero adjustments. (See paragraphs 4.7.1 and 4.7.2 for adjustment procedures.)

4.4.4 Further Isolation of Trouble

The high open-loop gains of the amplifier circuits on Preamplifier and 'Post' amplifier assemblies A2 and A3 tend to complicate isolation of trouble to individual stages and circuit elements. For example, signal pickup from oscilloscope or voltmeter leads, fed back from output to input of the 'Post' amplifier, may result in completely misleading indications. Because of this, many users will find that the fastest, most economical procedure (once trouble is isolated to A2 or A3) will be to replace the defective assembly with a spare (per instructions in section 4.5) and to return the faulty assembly to the nearest HP field office for repair.

If a spare assembly is not available, the entire amplifier may be returned to the field office, or an effort may be made to locate the trouble by signal tracing with oscilloscope and voltmeter. The theory of operation in section 3, the schematics and parts location illustrations in section 5, and the following additional information are provided to assist trouble isolation.

Power Supply Specifications

Preamplifier and 'Post' amplifier power supply output specifications are identical, as follows:

±18v outputs	DC: 18.5 ±1v AC ripple: < .01v rms
±6.2v outputs:	5.8 to 6.5v dc

Determine power supply voltage check points from Figure 5.3 through 5.6.

Power Supply Troubleshooting

DC Voltage	AC Ripple	Probable Cause
correct	high (60 Hz)	One rectifier open
correct	high (120 Hz)	300 μf capacitor open
correct	high (> 120 Hz)	.01 or 100 μf capacitor open, or noisy voltage reference diode
high	high	voltage reference diode or dc amplifier open – or series regulator shorted
high or low	correct	voltage reference diode out of tolerance
low	high	supply overloaded or T1 voltage low
none	none	thermal switch S4, T1 primary, or F1 open, or POWER switch not on.

Locating Noisy Stages

The easiest technique for locating a noisy stage on the Preamplifier or 'Post' amplifier is to touch the cases of the transistors, starting with the last transistor, and moving backward until the touching of a transistor has a noticeable effect upon the noise reading of the AC VTVM.

Locating Oscillating Stages

Oscillating stages in the Preamplifier or 'Post' amplifier are most often caused by an open feedback capacitor. Consequently, one of the most effective techniques for locating an oscillating stage is to temporarily connect a substitute capacitor of the correct value across the various feedback capacitors, one at a time, until oscillation is stopped. Install a new capacitor where the substitute capacitor has stopped oscillation.

4.5 REPAIR

4.5.1 Special Precautions

The performance of high-impedance analog circuits, such as those of the Preamplifier and the 'Post' amplifier, is degraded by contamination of the surface of the circuit board or components. Contaminants to be avoided are finger marks, oil droplets, and the rosin fluxes commonly used in soldering. To minimize the chance of contamination, the following precautions should be observed when replacing Preamplifier A2 or 'Post' amplifier A3:

1. Wear clean gloves at all times when handling the circuit board, or handle the board only by its edges or in areas not containing critical circuits. Handle critical components by leads or conducting surfaces rather than bodies or insulating surfaces.

2. Accomplish repairs in the cleanest environment available.

3. Do not use rosin-core solder; employ only the soldering technique detailed in paragraph 4.5.4.

4.5.2 Recommended Tools and Supplies

The following (or equivalent) tools and supplies are recommended for use in repairing the 2470A Data Amplifier:

1. Soldering Iron: 35-50 watt, Ungar number 776 handle with number 1237 heating unit and PL113 tip, manufactured by:

   Ungar Electric Tools
   2701 El Segundo Blvd.
   Hawthorne, California, 90252

2. Solder: Solid 60/40 tin-lead (no rosin)

3. Soldering Flux: number 1429 Organic Flux, manufactured by:

   Kester Solder Company
   4203 Wrightwood Ave.
   Chicago, Illinois 60639

4. Distilled Water (for flushing away organic flux after soldering)

5. Cleaning Solvent (for removal of contaminants from circuit board and component surfaces): Freon T-E35 (formerly Freon PC), available from:

   Dupont Freon Products Division
   701 Welsh Road
   Palo Alto, California

6. Long-Nose Pliers

4.5.3 Soldering Iron Temperature and Cleaniness

Use a soldering iron with 35-50 watt rating and chisel tip. Allow it to reach full operating temperature (about 800 °F) before unsoldering or soldering. A fully-heated iron assures quick completion of soldering and minimizes the chance that the etched wiring parts, or the board will be damaged by overheating. Before using the soldering iron, wipe it off to remove excess solder and oxides.

4.5.4 Replacement of Circuit Board

1. Gain access to the circuit board per instructions in section 4. 3, but do not remove snap fasteners.

2. Record the color coding of wires connected to the board being replaced to assure accurate rewiring. (This can be done while the soldering iron is heating.)

3. In the most convenient sequence, unsolder all external connections to the circuit board, using long-nose pliers with gentle pressure to pull the leads free as soon as the solder has become fluid.

NOTE

> Do not let the soldering iron touch the plastic case of the amplifier or the bodies of components, especially transistors or diodes.

4. Unsnap all fasteners and remove the circuit board.

5. Install the new circuit board, secure it in place with the snap fasteners, and shape and tin leads for soldering to the new board.

6. Barely moisten the points to which leads must be soldered, and only those points, with a mild, water-soluble, organic flux, such as Kester 1429, using a small brush.
7. Insert and solder leads to the correct points, referring to the record made in step 2 where necessary, using solder containing no flux, and applying heat and solder sparingly. Make certain all leads going to each point are connected before soldering them.
8. After all leads are correctly soldered to the new board, repeatedly flush the soldered points with distilled water and scrub and dry them to remove remaining traces of organic flux.
9. Replace the Preamplifier cover shield if it has been removed and calibrate the 2470A per applicable instructions in paragraphs 4. 7. 1 through 4. 7. 5.

4.6 CLEANING

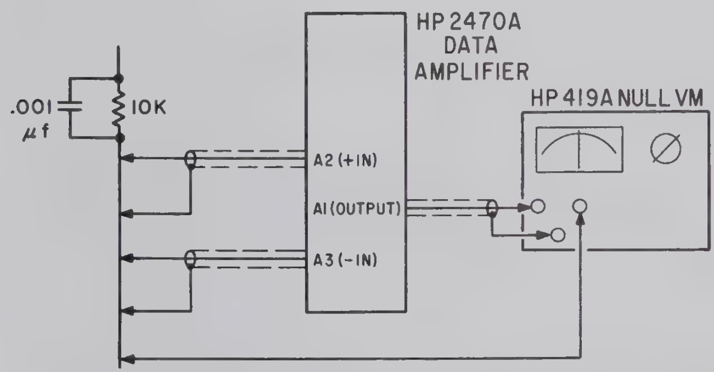
Routine cleaning of the 2470A Data Amplifier accomplished every 180 days, should consist only of vacuuming the interior. Air blast cleaning should be avoided because compressed air frequently contains very small droplets of oil which adhere to circuit boards and parts, causing rapid accumulation of dust and dirt and consequent deterioration of performance.

4.7 CALIBRATION

4.7.1 Preamplifier Internal Zeroing

Every 90 days, or after repair of the Preamplifier circuit, reset internal zero adjustments of the Preamplifier as follows:

1. Connect setup as shown in Figure 4. 2 and turn on all equipment. Note the time; the 2470A will require at least 30 minute warmup if provided forced air ventilation through it from rear to front at 1 cfm, minimum, or 1-1/2 hour warmup in free air.



SETUP FOR PREAMPLIFIER ZEROING
FIGURE 4.2

2. After correct warmup of 2470A, zero the Null VM and select 100 mv range.
3. Set the 2470A Multiplier to 100 and the Vernier (on 2470A-M3) full counter-clockwise to 000 and lock it there.

4. Set the front panel ZERO screwdriver) adjustment for a reading less than ±2 mv. (Switch the Null VM down range for reading in upper 2/3 of the scale.)

NOTE

If zero cannot be set within ±2 mv from the front panel, perform steps 5, 6 and 7. If zero sets correctly, skip to step 8.

5. Set the front panel ZERO adjustment to mid-range (10 turns from either extreme of adjustment).
6. Reset Null VM to 100 mv range.
7. Use Figure 5.2, page 5-5, to locate position of R45 on the Preamplifier board. Then, working quickly to minimize temperature change while the case is open, open the case and set R45 for a minimum reading (less than ±10 mv). Close the case immediately and repeat step 4.
8. Connect the 2470A +IN lead (A2 center contact) to the high side of the 10K unbalance resistor and check the Null VM reading. The reading should be less than ±5 mv. If the reading is greater, check Figure 5.2 for location of R4 on the Preamplifier board. Then, working quickly to minimize temperature change while the case is open, open the case and set R4 for a minimum reading (less than ±5 mv). Close the case immediately and proceed with step 9.
9. Reverse the connections of the 2470A +IN and -IN leads to the 10K unbalance resistor, without changing shield connections, and again check the Null VM reading. The reading should be less than ±5 mv. If the reading is greater, open the case and set R41 on the Preamplifier board for a minimum reading (less than ±5 mv). Work quickly and close the case immediately to minimize temperature change.

4.7.2 Zeroing 'Post' Amplifier

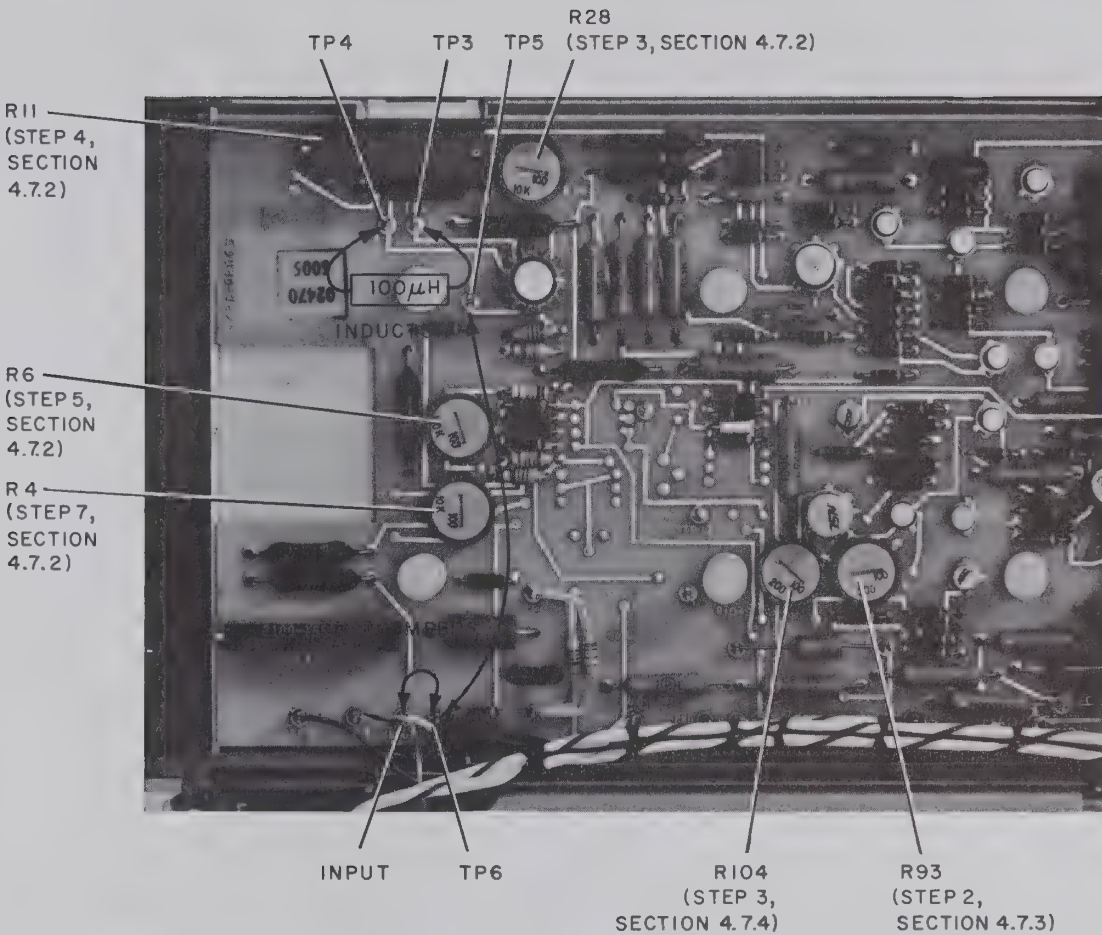
Every 90 days, or after repair of the 2470A, reset internal zero of the 'Post' amplifier assembly as follows:

1. Connect setup as shown in Figure 4.2 and turn on all equipment.
2. Set 2470A MULTIPLIER switch to 10, set the Null VM to 1 mv range, and check the meter. If reading is less than ±30μv (Null VM on 100 μv range) no adjustment is needed.

NOTE

If the meter reading is greater than ±250 μv, perform steps 3 through 7; if the meter reading is greater than ±30 μv, but not greater than ±250 μv, perform only step 7.

3. Temporarily connect a jumper between the 'Post' amplifier assembly 'input' and 'TP6' terminals, a jumper between 'TP5' and 'TP6' terminals, and a 100 microhenry inductor between the 'TP3' and 'TP4' terminals. Set R28 for minimum Null VM reading (less than ±1 millivolt). See Figure 4.3 for terminal and adjustment locations.

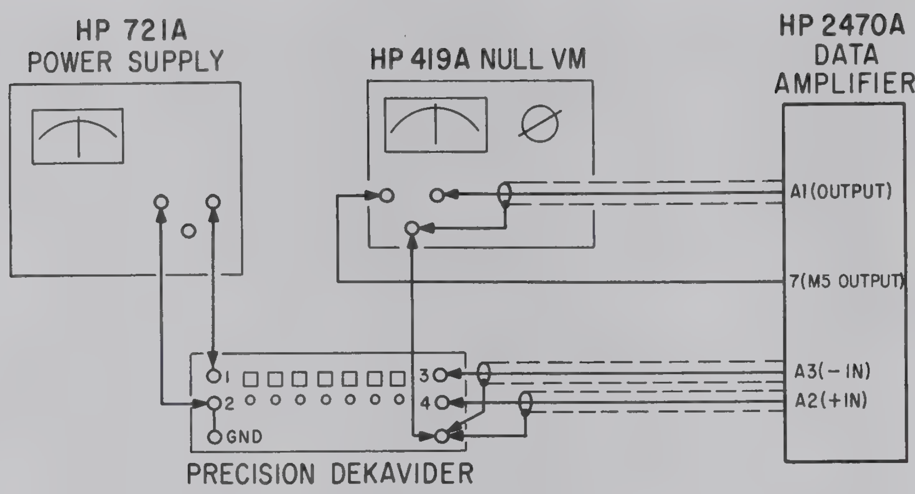


TERMINAL AND ADJUSTMENT LOCATIONS ON A3
FIGURE 4.3

4. Disconnect the 100 microhenry inductor from 'TP3' and 'TP4' and set R11 for minimum Null VM reading (less than ±1 mv).
5. Disconnect the short from 'TP5' and 'TP6', leaving the short between 'TP6' and the 'input' in place and set R6 for minimum Null VM reading (less than ±1 mv).
6. Disconnect the short from the 'input' and 'TP6' terminals.
7. Set R4 for minimum Null VM reading (less than ±30 μv).

4.7.3 Zeroing of Buffered Output (2470A-M5 Only)

1. After the preamplifier and post amplifier have been zeroed correctly, establish setup shown in Figure 4. 4 and set the Dekavider to 0000000.
2. If the Null VM reading is not less than 100 μv with the 2470A-M5 MULTIPLIER switch set to 10, open the amplifier and set R93 on the 'Post' amplifier board for minimum reading (within ±100 μv of zero). See Figure 4. 3 for location of R93. Then close the 2470A.



SETUP FOR CALIBRATING BUFFERED OUTPUT
FIGURE 4.4

4.7.4 Calibrating Buffered Output Gain (2470A-M5 Only)

1. Establish setup shown in Figure 4.4.
2. Set Power Supply for 10 volt output, the Dekavider to .100000, and the 2470A-M5 MULTIPLIER to 10.
3. If the Null VM reading is not less than ±1 mv, open the amplifier and set R104 on the 'Post' amplifier board for minimum reading (within ±1 mv of zero). See Figure 4.3 for location of R104.

4.7.5 Zeroing the Overload Detector (2470A-M4 Only)

1. With the MULTIPLIER set at 10, connect the center contact of the output lead from A1 to the shield.
2. Open the amplifier and connect '+' and '-' leads from the Null VM to 'TP12' and 'TP13' on the post amplifier. See Figure 5.5 for locations.
3. If the Null VM reading is not less than ±100 mv when the amplifier is turned on, adjust R79 for minimum reading (within ±100 mv of zero).

SECTION 5
REPLACEABLE PARTS

5.1 INTRODUCTION

This section contains identification and ordering information for replacement parts. The parts lists are accompanied by parts location illustrations and schematic diagrams. Any changes to the parts list tables will be listed on a change sheet at the rear of this manual. A part described as "hp only" is a special part that can be obtained only from the Hewlett-Packard Company. If another manufacturer's stock (part) number is listed, the part may be obtained directly from that manufacturer. A list of manufacturer's code numbers will be found in the Appendix at the end of this section. Usually, parts available from manufacturers other than those listed may be used when the part has equivalent electrical and physical characteristics and quality. '

As noted on the schematic diagrams in this section, the optimum electrical value of certain components may be selected at the factory to compensate for variations in other components, wiring capacitance, or to provide performance that is specified when the instrument is ordered. In some instruments, a selected part may be omitted (i. e. , a selected resistor might be a wire or an open circuit). The nominal or average value, or the range of values from which selection is made, may be indicated on the schematic diagram. When replacing a selected part, order a part with the value that was originally installed in your instrument.

The Table lists parts in alpha-numerical order of the reference designation and provides the following information for each part:

1. Description (see list of abbreviations used, paragraph 5.3).
2. hp stock number or Dymec drawing number.
3. Typical manufacturer of the part in a five-digit code (see list of manufacturers in the Appendix).
4. Manufacturer's part, stock, or drawing number.
5. Total quantity used in the instrument.
6. Recommended spare part quantity for complete maintenance durine one year of isolated service.

Miscellaneous and mechanical parts not indexed by reference designation are listed at the end of the Table.

5.2 ORDERING INFORMATION

To order a replacement part, address your order or inquiry either to your local Hewlett-Packard/Dymec field office (listed on the last page of this manual) or to:

United States

CUSTOMER SERVICE
Hewlett-Packard Co.
333 Logue Ave.
Mountain View, California 94040

Western Europe

Hewlett-Packard S. A.
54 Route des Acacias
Geneva, Switzerland

Specify the following information on each part:

1. Dymec model number and complete serial number of instrument.
2. (hp) stock number.
3. Circuit reference designation.
4. Description.

To order a part not listed in the Table, give complete description and include function and location of the part in the instrument and/or system.

5.3 ABBREVIATIONS USED

Reference Designation Column

A	= assembly	MP	= mechanical part
B	= motor	P	= plug
C	= capacitor	Q	= transistor
CR	= diode	R	= resistor
DL	= delay line	RT	= thermistor
DS	= device signaling (lamp)	RV	= varistor
E	= misc electronic part	S	= switch
F	= fuse	T	= transformer
FL	= filter	V	= vacuum tube, neon bulb, photo-cell, etc.
J	= jack		
K	= relay	W	= cable
L	= inductor	X	= socket
M	= meter	Z	= network

Description Column

a	= amperes	piv	= peak inverse voltage
c	= carbon	pos	= position(s)
cer	= ceramic	poly	= polystyrene
cflm	= carbon film	pot	= potentiometer
comp	= composition	rect	= rectifier
depc	= deposited carbon	rot	= rotary
elect	= electrolytic	s-b	= slow-blow
f	= farads	Se	= selenium
f-a	= fast acting	sect	= section(s)
fxd	= fixed	Si	= silicon
Ge	= germanium	SPL	= special
incd	= incandescent	Ta	= tantalum
metflm	= metal film	Ti	= titanium dioxide
MFR	= manufacturer	tog	= toggle
mtflm	= metal film	tol	= tolerance
my	= mylar	v	= volts
NC	= normally closed	var	= variable
Ne	= neon	w/	= with
NFR	= not field replaceable	w	= watts
NO	= normally open	ww	= wirewound
NPO	= zero tem coeff	w/o	= without
NSN	= no stock number	*	= optimum value selected, nominal value shown (component may be omitted)
NSR	= not separately replaceable		
OBD	= order by description		
pc	= printed circuit board		

5.4 RECOMMENDED INDUSTRIAL SPARES

In situations where down-time of the equipment is of critical importance, it is recommended that one of each of the following etched circuit boards or assemblies be stocked. Although they are not plug-in assemblies they are designed for fast, easy replacement. This instrument can then be kept in operation while the faulty board or assembly is being repaired. The items listed without designation or stock number are for page number reference only.

Ref. Des.	Assembly Description	Stock No.	Page No.
A1	Multiplier Switch	02470-6002	5-7
or:	(2470A-M1)		
A1M1	Multiplier Switch	02470-6003	5-7
and	(2470A Std, M1 and M3)		
A2	Preamplifier	02470-6007	5-7
A3	Post Amplifier	02470-6001	5-11
or:	(2470A-M4, alone or with M1 and/or M3)		
A3M4	Post Amplifier	02470-6004	5-13
or:	(2470A-M5, alone or with M1 and/or M3)		
A3M5	Post Amplifier	02470-6005	5-13
or:	(2470A-M4/M5, alone or with M1 and/or M3)		
A3M4/M5		02470-6006	5-14

NOTE

For easy location of parts and determination of functions, supporting illustrations face the parts lists wherever possible. The illustrations are:

* Unfold page 5-4 to view Figure 5.1 on this page

Specify the following information on each part:

1. Dymec model number and complete serial number of instrument.
2. (hp) stock number.
3. Circuit reference designation.
4. Description.

To order a part not listed in the Table, give complete description and include function and location of the part in the instrument and/or system.

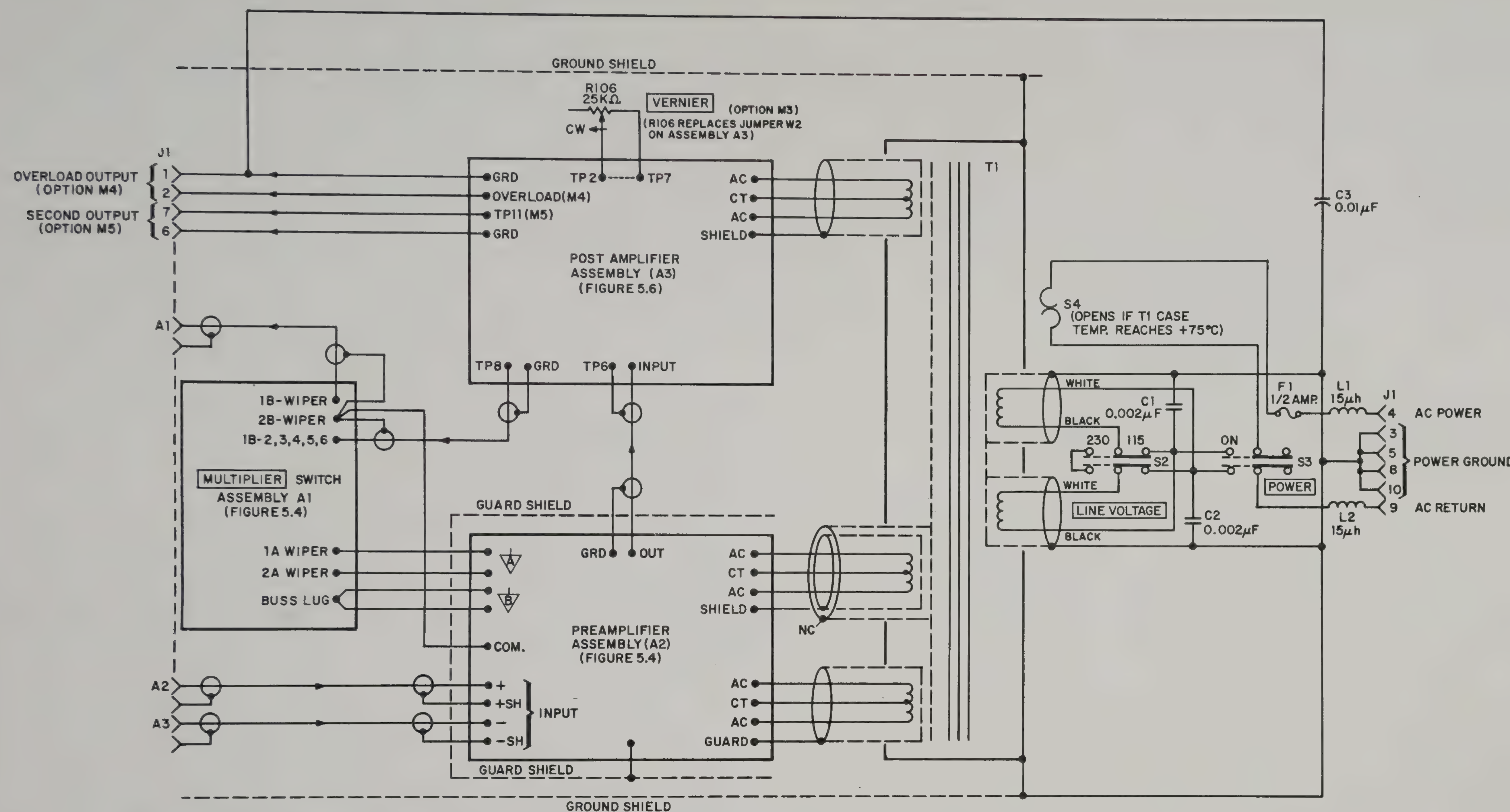
5.3 ABBREVIATIONS USED

Reference Designation Column

A	= assembly	MP	= mechanical part
B	= motor	P	= plug
C	= capacitor	Q	= transistor
CR	= diode	R	= resistor
DL	= delay line	RT	= thermistor
DS	= device signaling (lamp)	RV	= varistor
E	= misc electronic part	S	= switch
F	= fuse	T	= transformer
FL	= filter	V	= vacuum tube, neon bulb, photo-cell, etc.
J	= jack		
K	= relay	W	= cable
L	= inductor	X	= socket
M	= meter	Z	= network

Description Column

a	= amperes	piv	= peak inverse voltage
c	= carbon	pos	= position(s)
cer	= ceramic	poly	= polystyrene
cflm	= carbon film	pot	= potentiometer
comp	= composition	rect	= rectifier
depc	= deposited carbon	rot	= rotary
elect	= electrolytic	s-b	= slow-blow
f	= farads	Se	= selenium
f-a	= fast acting	sect	= section(s)
fxd	= fixed	Si	= silicon
Ge	= germanium	SPL	= special
incd	= incandescent	Ta	= tantalum
metflm	= metal film	Ti	= titanium dioxide
MFR	= manufacturer	tog	= toggle
mtflm	= metal film	tol	= tolerance
my	= mylar	v	= volts
NC	= normally closed	var	= variable
Ne	= neon	w/	= with
NFR	= not field replaceable	w	= watts
NO	= normally open	ww	= wirewound
NPO	= zero tem coeff	w/o	= without
NSN	= no stock number	*	= optimum value selected, nominal value shown (component may be omitted)
NSR	= not separately replaceable		
OBD	= order by description		
pc	= printed circuit board		

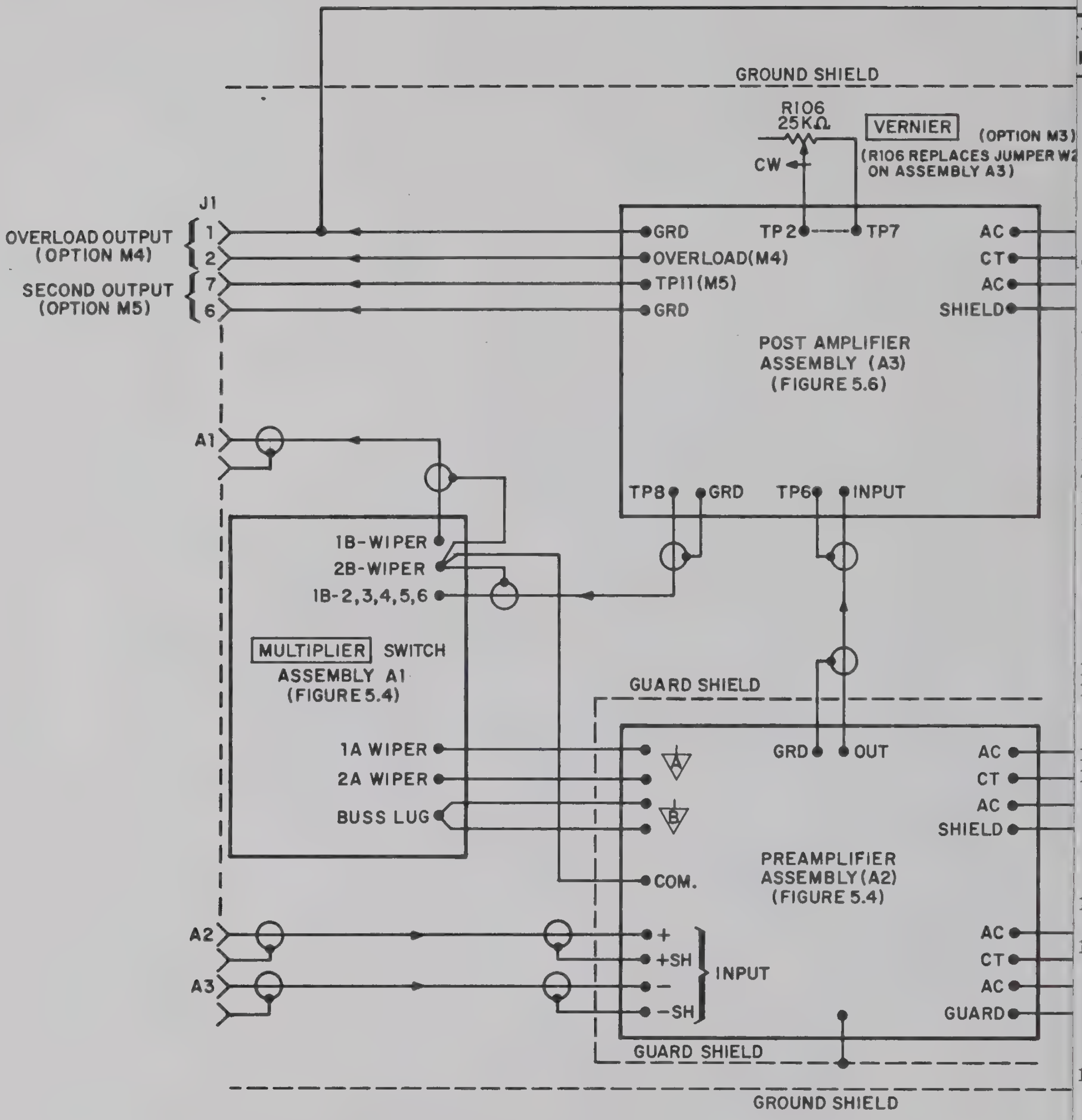


NOTE: FIGURE 5.4 SHOWS SCHEMATICS 02470-6002 (A1); 02470-6003 (A1M1), AND 02470-6007 (A2)
FIGURE 5.6 SHOWS SCHEMATIC 02470-9001 (A3M4/M5)
ARROWS INDICATE DIRECTION OF SIGNAL FLOW

C02470-9012

2470A OVERALL SCHEMATIC

FIGURE 5.1

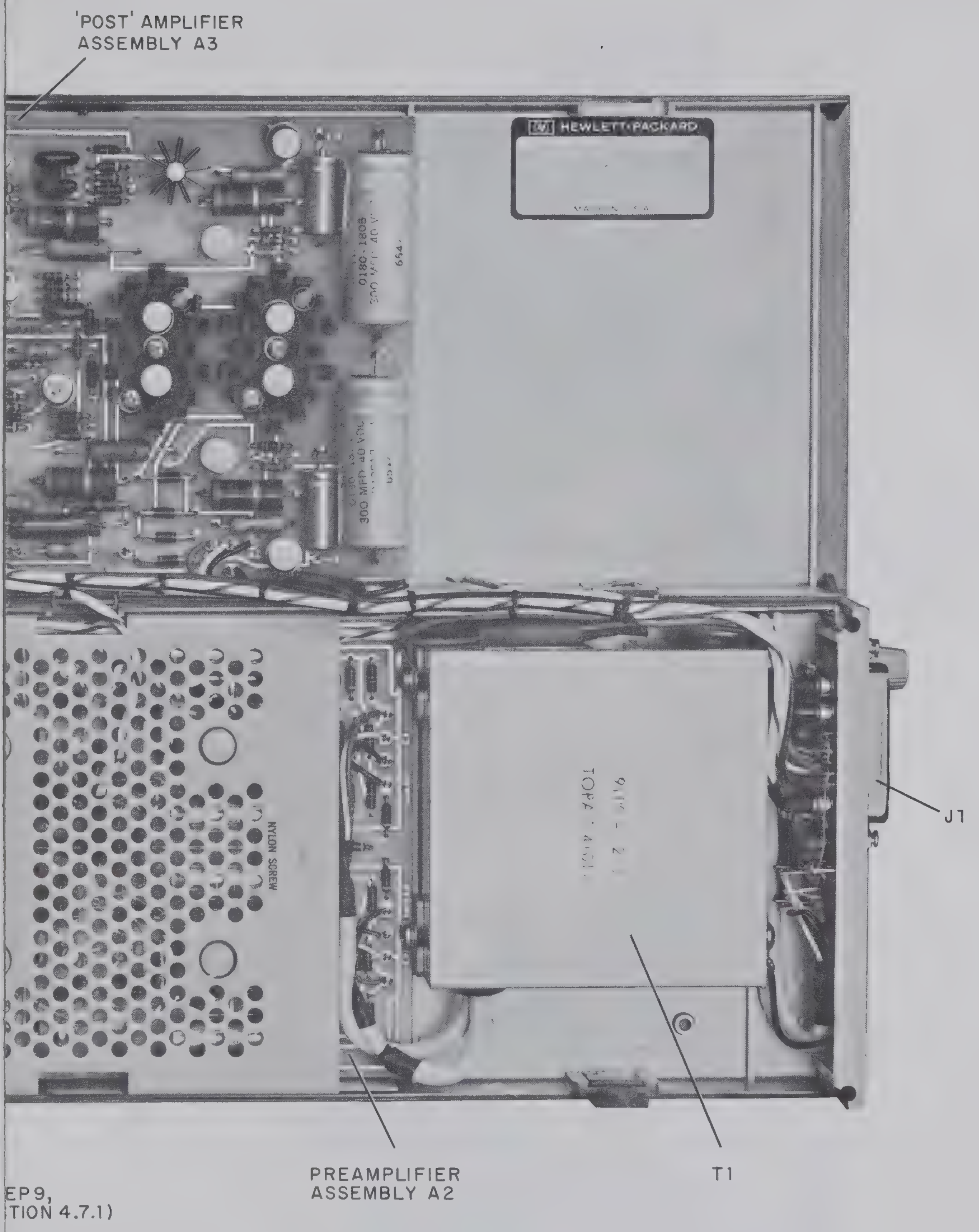


NOTE: FIGURE 5.4 SHOWS SCHEMATICS 02470-6002 (AI); 02470-6003 (AIMI), AND 02470-6007 (A2)
FIGURE 5.6 SHOWS SCHEMATIC 02470-9001 (A3M4/M5)
ARROWS INDICATE DIRECTION OF SIGNAL FLOW

C 02470-9012

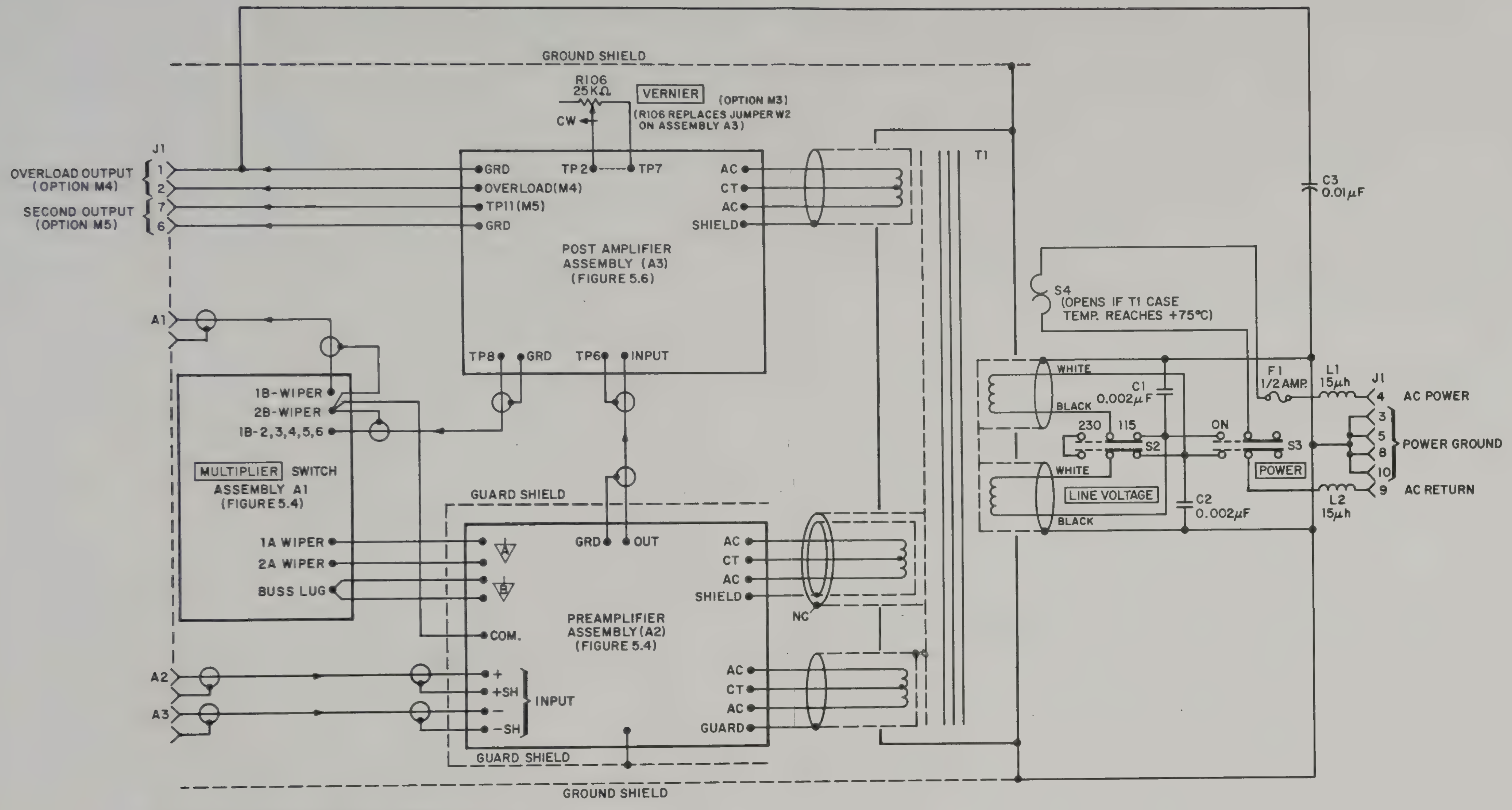
2470A OVERALL SCHEMATIC Unfold for Main Parts List

FIGURE 5.1



2470A PARTS AND ASSEMBLIES

FIGURE 5.2



NOTE: FIGURE 5.4 SHOWS SCHEMATICS 02470-6002 (A1); 02470-6003 (A1M1), AND 02470-6007 (A2)
FIGURE 5.6 SHOWS SCHEMATIC 02470-9001 (A3M4/M5)
ARROWS INDICATE DIRECTION OF SIGNAL FLOW

C02470-9012

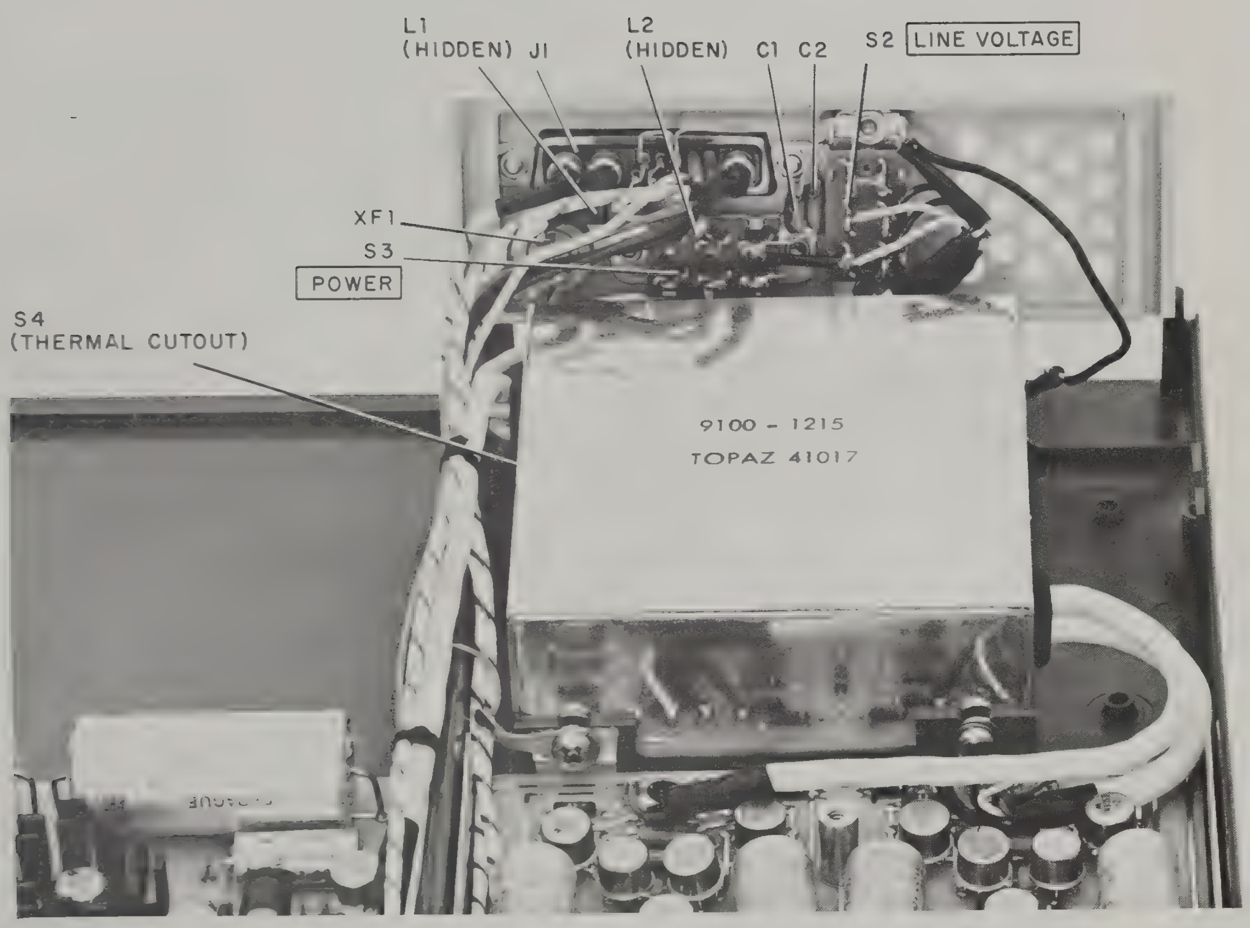
2470A OVERALL SCHEMATIC Unfold for Main Parts List

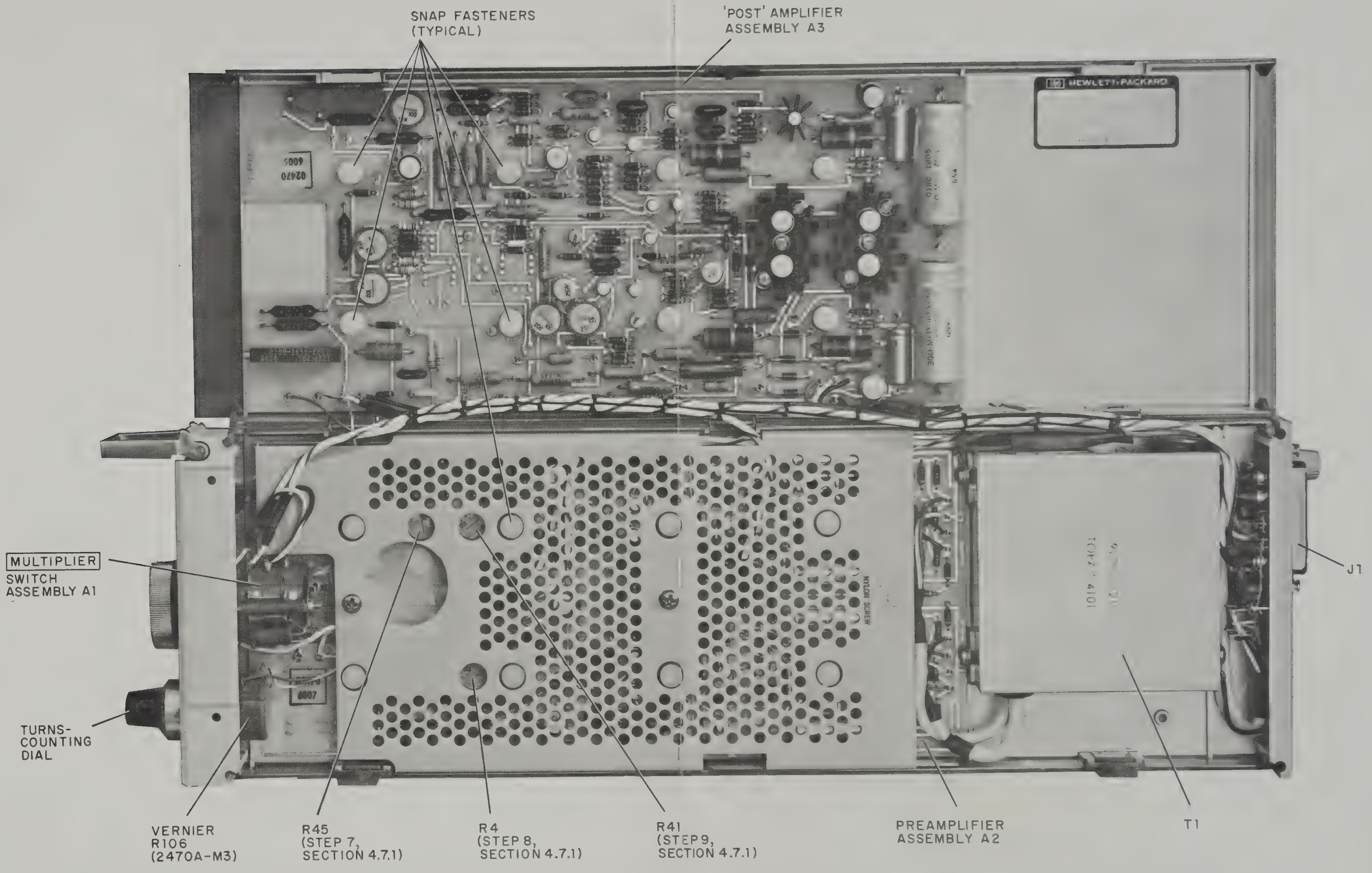
FIGURE 5.1

TABLE 5.1 MAIN PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	STANDARD 2470A:					
A1	Switch Assembly (MULTIPLIER)	02470-6002	04404		1	1
A2	Preamplifier Assembly	02470-6007	04404		1	1
A3	Post Amplifier Assembly	02470-6001	04404		1	1
C1, 2	C: fxd, cer, 0.002 μf, 20%, 1000v	0150-0023	84411	Type 126	2	1
C3	C: fxd, my, 0.01 μf, 10%, 200v	0160-0161	28480		1	1
F1	Fuse: 1/2A, Plug-in	2110-0046	28480		1	10
J1	Conn: receptacle, 10-contact, male	1251-0344	71468	DMB-13W3P	1	1
	Coaxial insert for J1	1251-0347	71468	DM-53740-5001	3	1
L1, 2	Inductor: fxd, 15 μh	9140-0082	95265	NA-15.0-I	2	2
S2	Switch: slide DPDT (LINE VOLTAGE)	3101-0033	82389	11A-1009	1	1
S3	Switch: slide DPDT (POWER)	3101-0011	82389	11A-1013	1	1
S4	Switch: thermal cutout 75°C	5080-6574	04404		1	1
T1	Transformer: power	9100-1215	28480		1	1
XF1	Fuseholder	1400-0110	28480		1	1
	Decal: knob center plate	7120-1243	04404		1	1
	Fastener, plastic, snap-on, snap-off	0510-0941	28480		16	4
	Knob Center Plate: plastic, molded	5040-1433	04404		1	1
	Knob for XF1	1400-0112	28480		1	1
	2470A-M1:					
	Replace:					
A1	Switch Assembly (MULTIPLIER)	02470-6002	04404		1	1
	Decal: knob center plate	7120-1243	04404		1	1
	With:					
A1M1	Switch Assembly (MULTIPLIER)	02470-6003	04404		1	1
	Decal: knob center plate	7120-1242	04404		1	1
	2470A-M3:					
	Add:					
R106	R: var, ww, 25K, 3%, ten-turn, 0.25% linearity (VERNIER)	2100-1993	80294	3500S-1-70-253	1	1
	Dial: turns counting for R106	1140-0013	73138	Model 2601	1	1
	2470A-M4:					
	Replace:					
A3	Post Amplifier Assembly	02470-6001	04404		1	1
	With:					
A3M4	Post Amplifier Assembly	02470-6004	04404		1	1
	2470A-M5:					
	Replace:					
A3	Post Amplifier Assembly	02470-6001	04404		1	1
	With:					
A3M5	Post Amplifier Assembly	02470-6005	04404		1	1
	2470A-M4/M5:					
	Replace:					
A3	Post Amplifier Assembly	02470-6001	04404		1	1
	With:					
A3M4/M5	Post Amplifier Assembly	02470-6006	04404		1	1

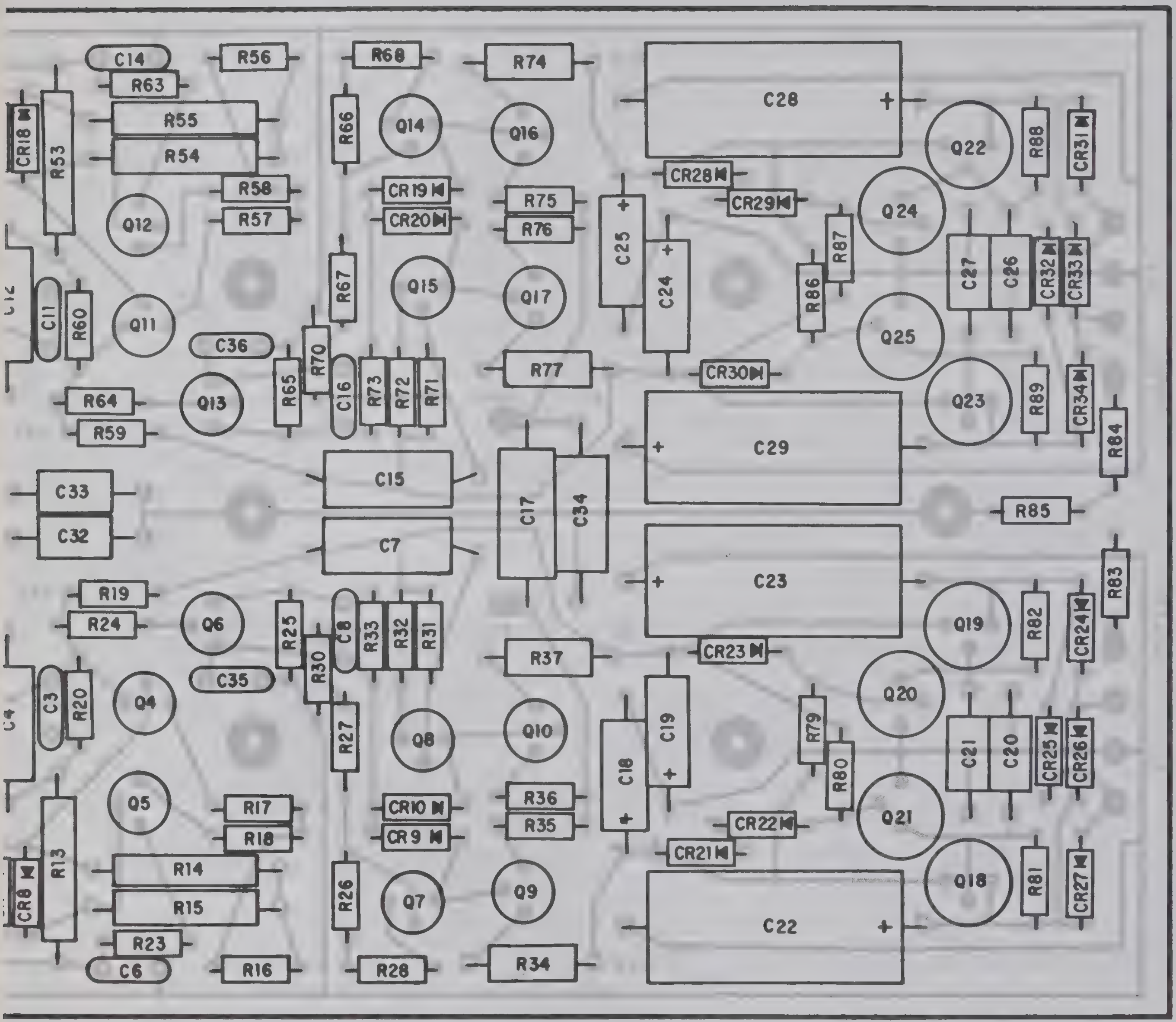
M0183





2470A PARTS AND ASSEMBLIES

FIGURE 5.2



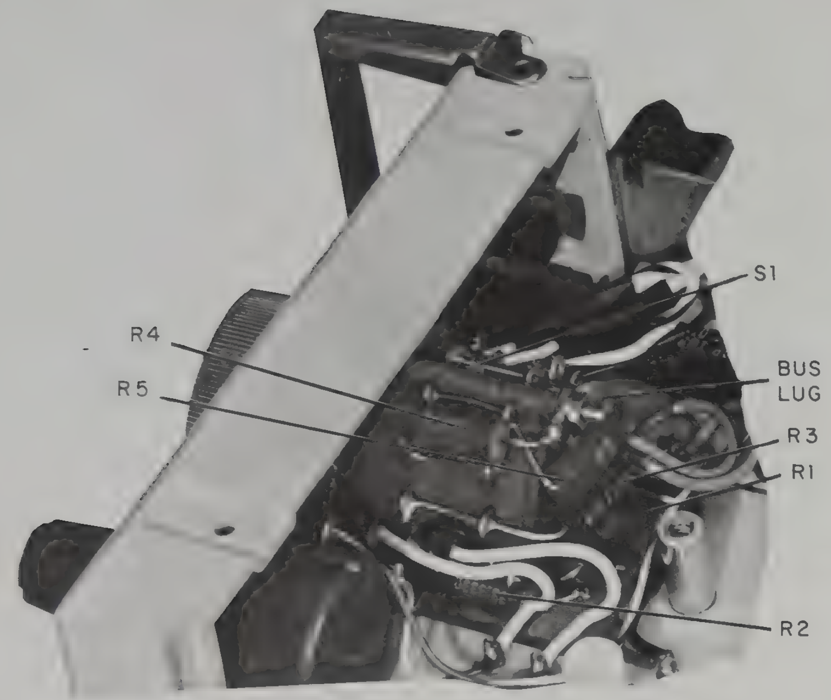
PARTS ON ASSEMBLIES A1, A1M1, AND A2

FIGURE 5.3

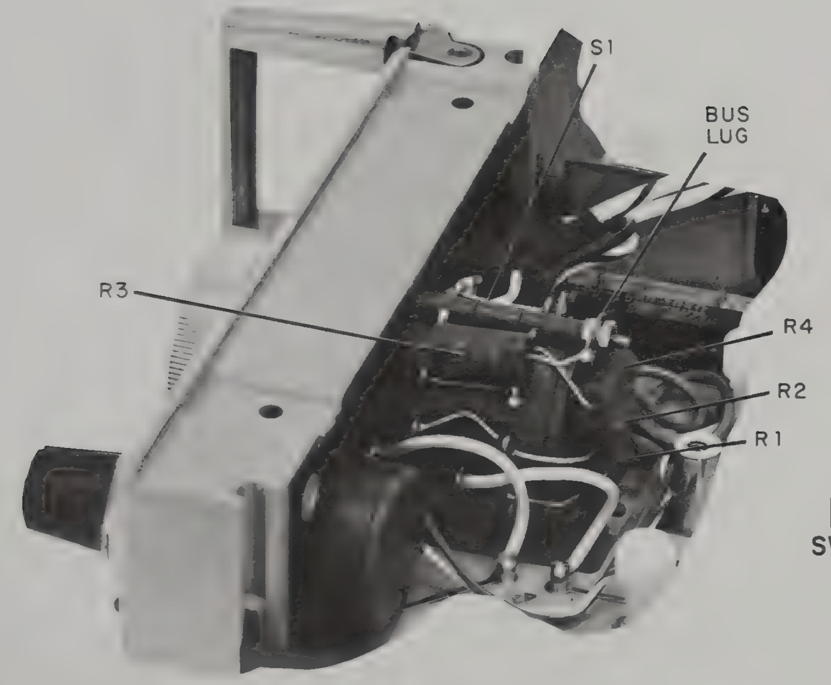
CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
A1	**MULTIPLIER SWITCH ASSEMBLY**	**02470-6002**	**04404**			
E1	Lug: solder, buss	5020-5117	28480		1	1
R1	R: fxd, ww, 10 ohms, 0.01%, ±5 ppm/°C	0811-1693	28480		1	1
R2	R: fxd, ww, 33.333 ohms, 0.01%, ±5 ppm/°C	0811-1695	28480		1	1
R3	R: fxd, ww, 100 ohms, 0.01%, ±5 ppm/°C	0811-1694	28480		1	1
R4	R: fxd, ww, 333.33 ohms, 0.01%, ±5 ppm/°C	0811-1696	28480		1	1
R5	R: fxd, ww, 1000 ohms, 0.01%, ±5 ppm/°C	0811-1697	28480		1	1
S1	Switch: rotary, 4 pole, 6 position	3100-1409	83332*		1	1
A1M1	**MULTIPLIER SWITCH ASSEMBLY** (replaces A1 in 2470A-M1 instruments)	**02470-6003**	**04404**			
E1	Lug: solder, buss	5020-5117	28480		1	1
R1	R: fxd, ww, 10 ohms, 0.01%, ±5 ppm/°C	0811-1693	28480		1	1
R2	R: fxd, ww, 100 ohms, 0.01%, ±5 ppm/°C	0811-1694	28480		1	1
R3	R: fxd, ww, 1000 ohms, 0.01%, ±5 ppm/°C	0811-1697	28480		1	1
R4	R: fxd, ww, 10,000 ohms, 0.01%, ±5 ppm/°C	0811-1701	28480		1	1
S1	Switch: rotary, 4 pole, 6 position	3100-1409	28480		1	1
A2	**PREAMPLIFIER ASSEMBLY**	**02470-6007**	**04404**			
C1, 2, 9, 10	C: fxd, my, 0.015 μf, 10%, 200v	0160-0194	28480		4	1
C3, 6, 11, 14	C: fxd, mica, 270 pf, 5%, 500v	0140-0206	04062	DM15F271J500v	4	1
C4, 12	C: fxd, my, 0.0047 μf, 10%, 200v	0160-0157	28480		2	1
C5, 13, 20, 21, 26, 27	C: fxd, my, 0.001 μf, 10%, 200v	0160-0163	28480		6	1
C7, 15	C: fxd, my, 0.047 μf, 10%, 200v	0170-0040	28480		2	1
C8, 16	C: fxd, mica, 680 pf, 5%, 500v	0140-0208	04062	DM15F681J3C	2	1
C17	C: fxd, my, 0.018 μf, 10%, 200v	0160-0302	28480		1	1
C18, 19, 24, 25	C: fxd, Ta, 4.7 μf, 10%, 35v	0180-0100	28480	150D475X9035B2	4	2
C22, 23, 28, 29	C: fxd, elect, 75 μf, -10%, +75%, 40v	0180-0277	28480		4	2
C32, 33	C: fxd, my, 0.0018 μf, 10%, 200v	0160-0299	28480		2	1
C34	C: fxd, my, 0.01 μf, 10%, 200v	0160-0161	28480		1	1
C35, 36	C: fxd, mica, 22 pf, 5%, 500v	0140-0145	04062	DM15C220J	2	1
CR2, 3, 12, 13	Diode: Ge	1910-0016	93332	D2361	4	3
CR4, 9, 10, 14, 19, 20	Diode: Si	1901-0025	28480		6	3
CR5, 15	Diode: Si	1901-0156	28480		2	2
CR6, 16	Diode: avalanche, 6.2v	1902-0777	28480		2	2
CR7, 8, 17, 18	Diode: Si	1901-0081	28480		4	3
CR21, 22, 28, 29	Diode: avalanche, 9v	1902-0772	04713		4	3
CR23, 30	Diode: Si, avalanche, 17.8v	1902-3224	28480		2	2
CR24-27, 31-34	Diode: Si	1901-0033	03877	1N485B	8	4
L1, 2	Inductor: coil, fxd, 15 μh, 1.2Ω, RF	9140-0082	95265	NA-15.0-I	2	1
Q1	Transistor, dual: Si, NPN	1854-0208	28480		1	1
Q2, 3	Transistor, dual: Si, NPN	1854-0207	28480		2	1
Q4-5, 11-12	Selected Transistor Pair: Si, PNP	5080-5964	04404		2	1

M0183

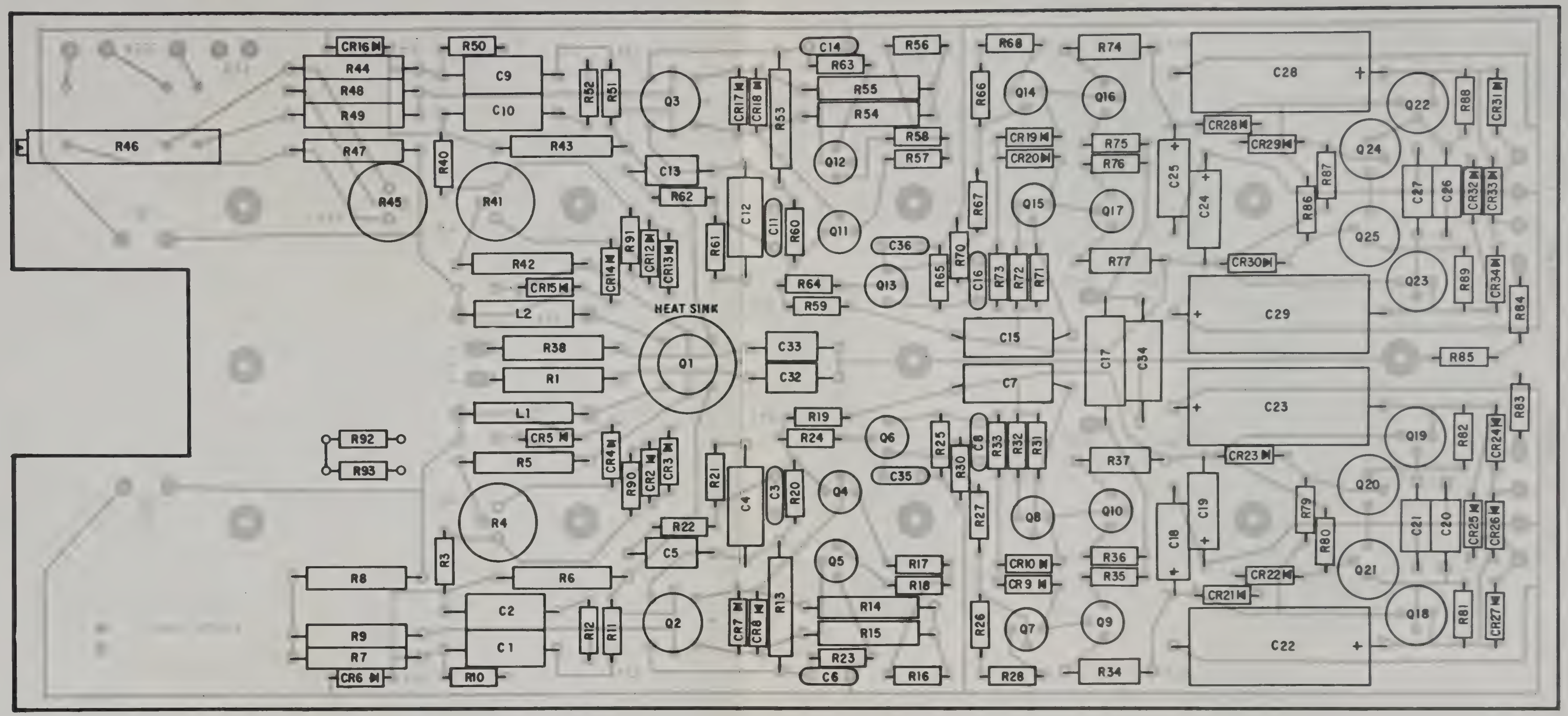
*Not on Mfr. Code Listing - Tech Labs, Sufferin, New York



MULTIPLIER
SWITCH ASSEMBLY
A1



MULTIPLIER
SWITCH ASSEMBLY
A1M1



PARTS ON ASSEMBLIES A1, A1M1, AND A2

FIGURE 5.3

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
A1	**MULTIPLIER SWITCH ASSEMBLY**	**02470-6002**	**04404**			
E1	Lug: solder, buss	5020-5117	28480		1	1
R1	R: fxd, ww, 10 ohms, 0.01%, ±5 ppm/°C	0811-1693	28480		1	1
R2	R: fxd, ww, 33.333 ohms, 0.01%, ±5 ppm/°C	0811-1695	28480		1	1
R3	R: fxd, ww, 100 ohms, 0.01%, ±5 ppm/°C	0811-1694	28480		1	1
R4	R: fxd, ww, 333.33 ohms, 0.01%, ±5 ppm/°C	0811-1696	28480		1	1
R5	R: fxd, ww, 1000 ohms, 0.01%, ±5 ppm/°C	0811-1697	28480		1	1
S1	Switch: rotary, 4 pole, 6 position	3100-1409	83332*		1	1
A1M1	**MULTIPLIER SWITCH ASSEMBLY** (replaces A1 in 2470A-M1 instruments)	**02470-6003**	**04404**			
E1	Lug: solder, buss	5020-5117	28480		1	1
R1	R: fxd, ww, 10 ohms, 0.01%, ±5 ppm/°C	0811-1693	28480		1	1
R2	R: fxd, ww, 100 ohms, 0.01%, ±5 ppm/°C	0811-1694	28480		1	1
R3	R: fxd, ww, 1000 ohms, 0.01%, ±5 ppm/°C	0811-1697	28480		1	1
R4	R: fxd, ww, 10,000 ohms, 0.01%, ±5 ppm/°C	0811-1701	28480		1	1
S1	Switch: rotary, 4 pole, 6 position	3100-1409	28480		1	1
A2	**PREAMPLIFIER ASSEMBLY**	**02470-6007**	**04404**			
C1, 2, 9, 10	C: fxd, my, 0.015 μf, 10%, 200v	0160-0194	28480		4	1
C3, 6, 11, 14	C: fxd, mica, 270 pf, 5%, 500v	0140-0206	04062	DM15F271J500v	4	1
C4, 12	C: fxd, my, 0.0047 μf, 10%, 200v	0160-0157	28480		2	1
C5, 13, 20, 21, 26, 27	C: fxd, my, 0.001 μf, 10%, 200v	0160-0163	28480		6	1
C7, 15	C: fxd, my, 0.047 μf, 10%, 200v	0170-0040	28480		2	1
C8, 16	C: fxd, mica, 680 pf, 5%, 500v	0140-0208	04062	DM15F681J3C	2	1
C17	C: fxd, my, 0.018 μf, 10%, 200v	0160-0302	28480		1	1
C18, 19, 24, 25	C: fxd, Ta, 4.7 μf, 10%, 35v	0180-0100	28480	150D475X9035B2	4	2
C22, 23, 28, 29	C: fxd, elect, 75 μf, -10%, +75%, 40v	0180-0277	28480		4	2
C32, 33	C: fxd, my, 0.0018 μf, 10%, 200v	0160-0299	28480		2	1
C34	C: fxd, my, 0.01 μf, 10%, 200v	0160-0161	28480		1	1
C35, 36	C: fxd, mica, 22 pf, 5%, 500v	0140-0145	04062	DM15C220J	2	1
CR2, 3, 12, 13	Diode: Ge	1910-0016	93332	D2361	4	3
CR4, 9, 10, 14, 19, 20	Diode: Si	1901-0025	28480		6	3
CR5, 15	Diode: Si	1901-0156	28480		2	2
CR6, 16	Diode: avalanche, 6.2v	1902-0777	28480		2	2
CR7, 8, 17, 18	Diode: Si	1901-0081	28480		4	3
CR21, 22, 28, 29	Diode: avalanche, 9v	1902-0772	04713		4	3
CR23, 30	Diode: Si, avalanche, 17.8v	1902-3224	28480		2	2
CR24-27, 31-34	Diode: Si	1901-0033	03877	1N485B	8	4
L1, 2	Inductor: coil, fxd, 15 μh, 1.2Ω, RF	9140-0082	95265	NA-15.0-I	2	1
Q1	Transistor, dual: Si, NPN	1854-0208	28480		1	1
Q2, 3	Transistor, dual: Si, NPN	1854-0207	28480		2	1
Q4-5, 11-12	Selected Transistor Pair: Si, PNP	5080-5964	04404		2	1

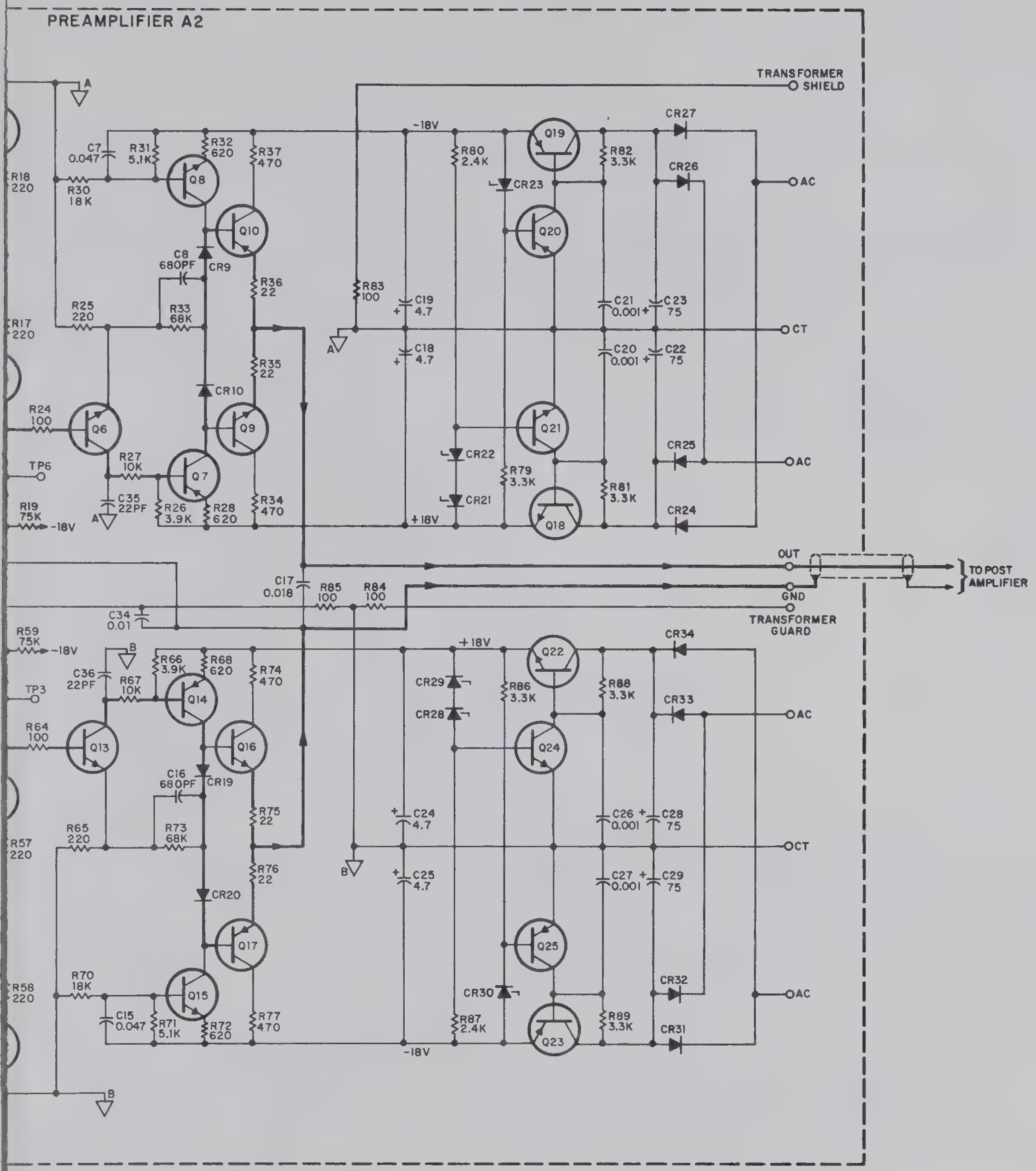
M0183

*Not on Mfr. Code Listing - Tech Labs, Sufferin, New York

TABLE 5.2 (Cont'd)

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	PREAMPLIFIER ASSEMBLY A2 (Cont'd)					
Q6,13	Transistor: si, NPN	1854-0211	04713	2N2501	2	1
Q7,10,14,17	Transistor: si, PNP	1853-0008	04713	2N3250	4	1
Q8,9,15,16	Transistor: si, NPN	1854-0212	02735	2N2897	4	1
Q18,22	Transistor: si, NPN	1854-0039	04713	2N3053	2	1
Q19,20,23, 25	Transistor: si, PNP	1853-0001	28480		4	1
Q21,24	Transistor: si, NPN	1854-0003	28480		2	1
R1,38	R: fxd, cflm, 1K, 1%, 1/2w	0727-0100	28480		2	1
R3,40	R: fxd, mtflm, 100K, 2%, 1/8w	0757-0972	28480		2	1
R4,41	R: var, ww, 10K, 5%, 1w	2100-0363	28480		2	1
R5,42	R: fxd, cflm, 1.96 Meg, 1%, 1/2w	0727-0847	28480		2	1
R6,14,15, 43,54,55	R: fxd, mtflm, 56.2K, 1%, 1/2w	0698-4321	28480		6	2
R7	R: fxd, mtflm, 5.62K, 1%, 1/2w	0698-4317	28480		1	1
R8,47	R: fxd, mtflm, 28.7K, 1%, 1/2w	0698-4319	28480		2	1
R9,48	R: fxd, mtflm, 51.1K, 1%, 1/2w	0698-4320	28480		2	1
R10,50	R: fxd, mtflm, 1.6K, 1%, 1/8w	0757-0929	28480		2	1
R11,51	R: fxd, mtflm, 2.7K, 2%, 1/8w	0757-0934	28480		2	1
R12,52	R: fxd, mtflm, 1.3K, 2%, 1/8 w	0757-0927	28480		2	1
R13,53	R: fxd, mtflm, 825 ohms, 1%, 1/2w	0698-4310	28480		2	1
R16,22,26, 56,62,66	R: fxd, mtflm, 3.9K, 2%, 1/8w	0757-0938	28480		6	2
R17,18,25, 57,58,65	R: fxd, mtflm, 220 ohms, 2%, 1/8w	0757-0908	28480		6	2
R19,59	R: fxd, mtflm, 75K, 2%, 1/8w	0757-0969	28480		2	1
R20,60	R: fxd, mtflm, 82K, 2%, 1/8w	0757-0970	28480		2	1
R21,61	R: fxd, mtflm, 22K, 2%, 1/8w	0757-0956	28480		2	1
R23,63	R: fxd, mtflm, 91K, 2%, 1/8w	0757-0971	28480		2	1
R24,64, 83-85	R: fxd, mtflm, 100 ohms, 2%, 1/8w	0757-0900	28480		5	2
R27,67	R: fxd, mtflm, 10K, 2%, 1/8w	0757-0948	28480		2	1
R28,32,68 72	R: fxd, mtflm, 620 ohms, 2%, 1/8w	0757-0919	28480		4	2
R30,70	R: fxd, mtflm, 18K, 2%, 1/8w	0757-0954	28480		2	1
R31,71	R: fxd, mtflm, 5.1K, 2%, 1/8w	0757-0941	28480		2	1
R33,73	R: fxd, mtflm, 68K, 2%, 1/8w	0757-0968	28480		2	1
R34,37,74, 77	R: fxd, comp, 470 ohms, 5%, 1/2w	0686-4715	28480		4	2
R35,36,75, 76	R: fxd, comp, 22 ohms, 5%, 1/4w	0683-2205	28480		4	2
R44	R: fxd, mtflm, 4.87K, 1%, 1/2w	0698-4315	28480		1	1
R45	R: var, ww, 2.5K, 5%, 1w	2100-1451	28480		1	1
R46	R: var, ww, 10K, 10%, 1w, 20 turns, (ZERO)	2100-1660	28480		1	1
R49	R: fxd, cflm, 1 Megohm, 1%, 1/2w	0727-0274	28480		1	1
R79,81,82 86,88,89, 90,91	R: fxd, mtflm, 3.3K, 2%, 1/8w	0757-0936	28480		8	3
R80,87	R: fxd, mtflm, 2.4K, 2%, 1/8w	0757-0933	28480		2	1
R92,93	R: fxd, comp, 2.2 Meg, 5%, 1/4w	0683-2255	28480		2	1

M0183



MULTIPLIER SWITCH ASSEMBLY A1, A1M1 &
PREAMPLIFIER ASSEMBLY A2 SCHEMATICS

FIGURE 5.4

TABLE 5.2 (Cont'd)

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	PREAMPLIFIER ASSEMBLY A2 (Cont'd)					
Q6, 13	Transistor: si, NPN	1854-0211	04713	2N2501	2	1
Q7, 10, 14, 17	Transistor: si, PNP	1853-0008	04713	2N3250	4	1
Q8, 9, 15, 16	Transistor: si, NPN	1854-0212	02735	2N2897	4	1
Q18, 22	Transistor: si, NPN	1854-0039	04713	2N3053	2	1
Q19, 20, 23, 25	Transistor: si, PNP	1853-0001	28480		4	1
Q21, 24	Transistor: si, NPN	1854-0003	28480		2	1
R1, 38	R: fxd, cflm, 1K, 1%, 1/2w	0727-0100	28480		2	1
R3, 40	R: fxd, mtflm, 100K, 2%, 1/8w	0757-0972	28480		2	1
R4, 41	R: var, ww, 10K, 5%, 1w	2100-0363	28480		2	1
R5, 42	R: fxd, cflm, 1.96 Meg, 1%, 1/2w	0727-0847	28480		2	1
R6, 14, 15, 43, 54, 55	R: fxd, mtflm, 56.2K, 1%, 1/2w	0698-4321	28480		6	2
R7	R: fxd, mtflm, 5.62K, 1%, 1/2w	0698-4317	28480		1	1
R8, 47	R: fxd, mtflm, 28.7K, 1%, 1/2w	0698-4319	28480		2	1
R9, 48	R: fxd, mtflm, 51.1K, 1%, 1/2w	0698-4320	28480		2	1
R10, 50	R: fxd, mtflm, 1.6K, 1%, 1/8w	0757-0929	28480		2	1
R11, 51	R: fxd, mtflm, 2.7K, 2%, 1/8w	0757-0934	28480		2	1
R12, 52	R: fxd, mtflm, 1.3K, 2%, 1/8 w	0757-0927	28480		2	1
R13, 53	R: fxd, mtflm, 825 ohms, 1%, 1/2w	0698-4310	28480		2	1
R16, 22, 26, 56, 62, 66	R: fxd, mtflm, 3.9K, 2%, 1/8w	0757-0938	28480		6	2
R17, 18, 25, 57, 58, 65	R: fxd, mtflm, 220 ohms, 2%, 1/8w	0757-0908	28480		6	2
R19, 59	R: fxd, mtflm, 75K, 2%, 1/8w	0757-0969	28480		2	1
R20, 60	R: fxd, mtflm, 82K, 2%, 1/8w	0757-0970	28480		2	1
R21, 61	R: fxd, mtflm, 22K, 2%, 1/8w	0757-0956	28480		2	1
R23, 63	R: fxd, mtflm, 91K, 2%, 1/8w	0757-0971	28480		2	1
R24, 64, 83-85	R: fxd, mtflm, 100 ohms, 2%, 1/8w	0757-0900	28480		5	2
R27, 67	R: fxd, mtflm, 10K, 2%, 1/8w	0757-0948	28480		2	1
R28, 32, 68 72	R: fxd, mtflm, 620 ohms, 2%, 1/8w	0757-0919	28480		4	2
R30, 70	R: fxd, mtflm, 18K, 2%, 1/8w	0757-0954	28480		2	1
R31, 71	R: fxd, mtflm, 5.1K, 2%, 1/8w	0757-0941	28480		2	1
R33, 73	R: fxd, mtflm, 68K, 2%, 1/8w	0757-0968	28480		2	1
R34, 37, 74, 77	R: fxd, comp, 470 ohms, 5%, 1/2w	0686-4715	28480		4	2
R35, 36, 75, 76	R: fxd, comp, 22 ohms, 5%, 1/4w	0683-2205	28480		4	2
R44	R: fxd, mtflm, 4.87K, 1%, 1/2w	0698-4315	28480		1	1
R45	R: var, ww, 2.5K, 5%, 1w	2100-1451	28480		1	1
R46	R: var, ww, 10K, 10%, 1w, 20 turns, (ZERO)	2100-1660	28480		1	1
R49	R: fxd, cflm, 1 Megohm, 1%, 1/2w	0727-0274	28480		1	1
R79, 81, 82 86, 88, 89, 90, 91	R: fxd, mtflm, 3.3K, 2%, 1/8w	0757-0936	28480		8	3
R80, 87	R: fxd, mtflm, 2.4K, 2%, 1/8w	0757-0933	28480		2	1
R92, 93	R: fxd, comp, 2.2 Meg, 5%, 1/4w	0683-2255	28480		2	1

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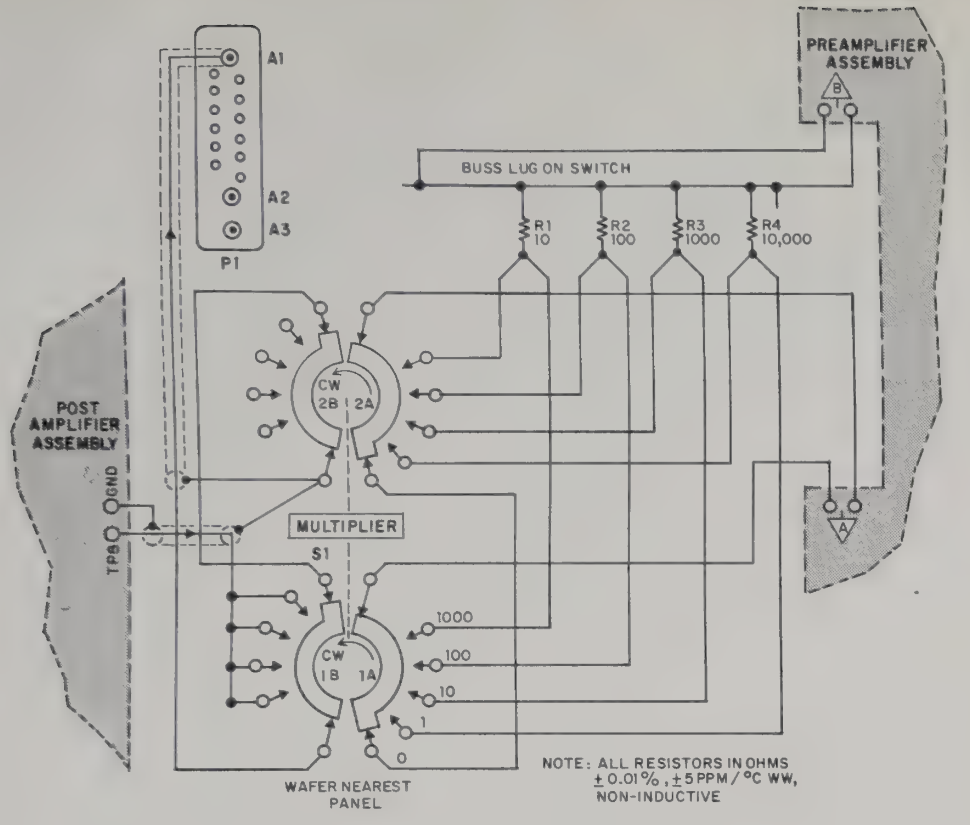
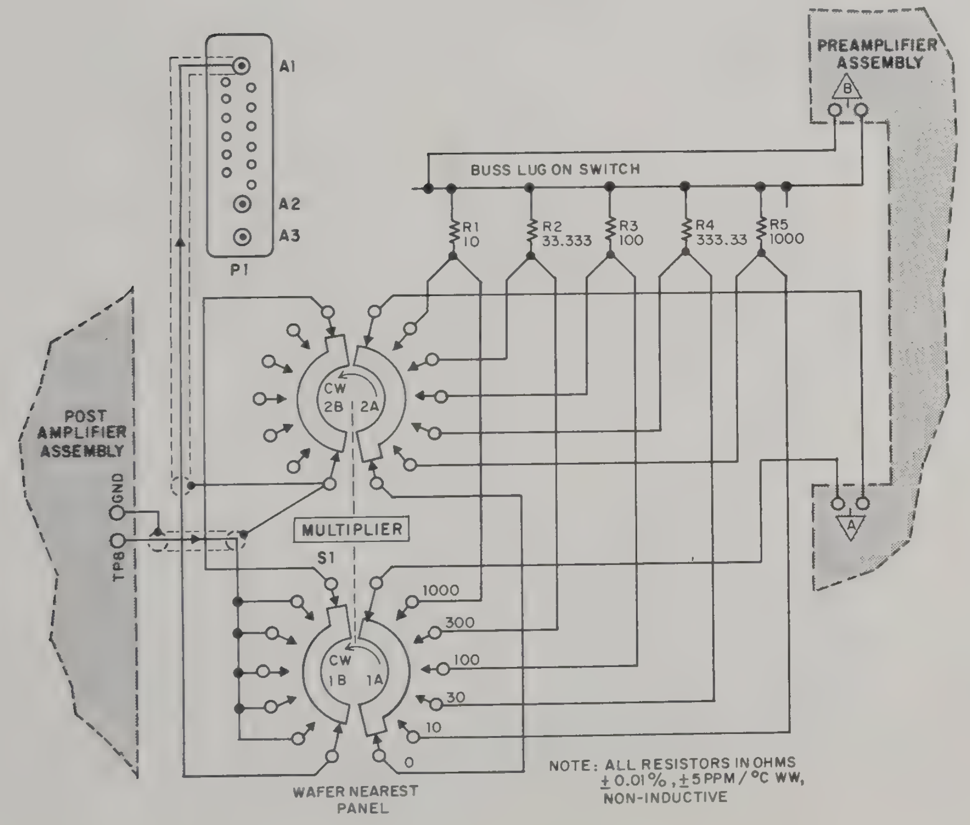
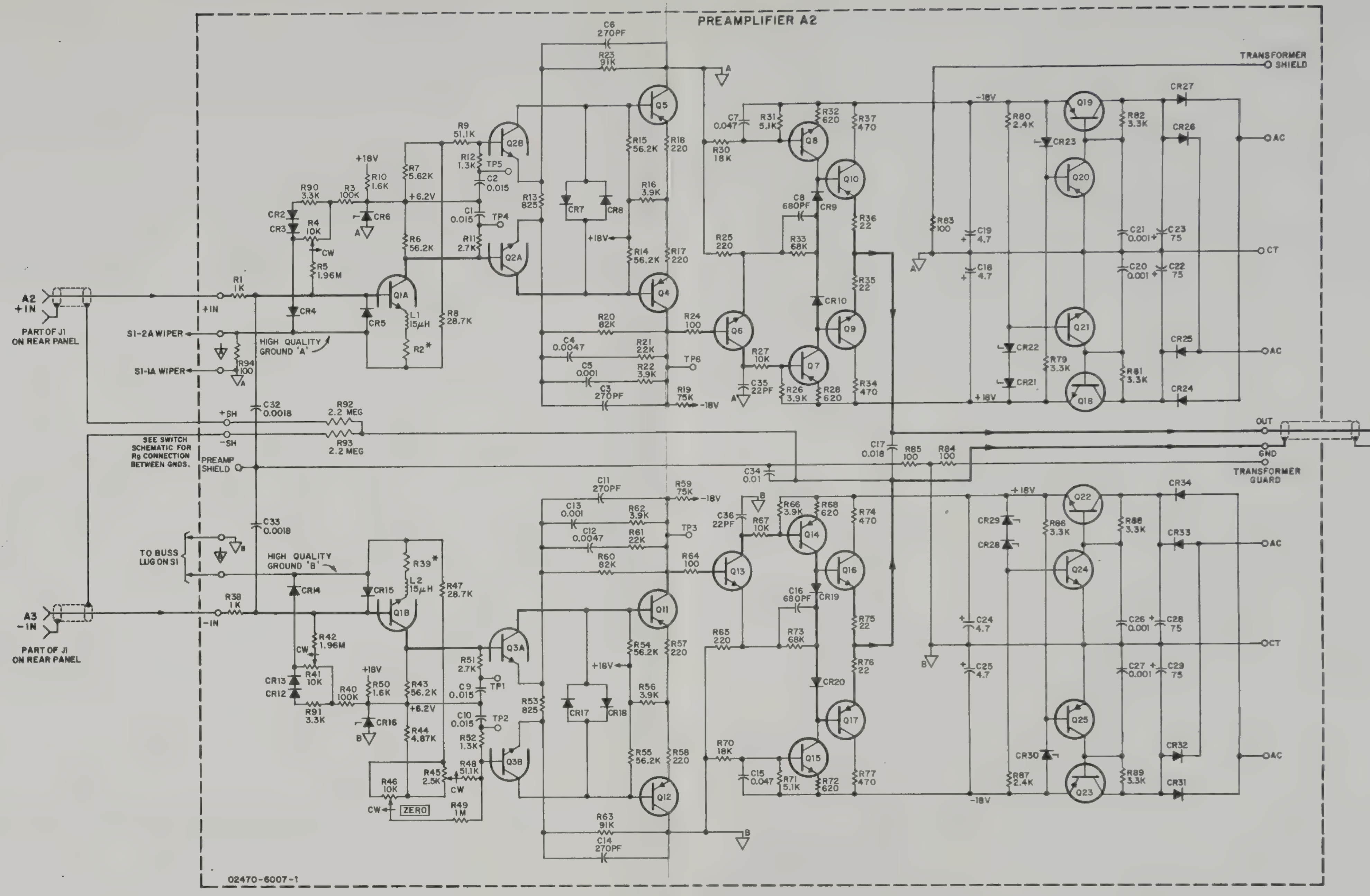


MULTIPLIER SWITCH ASSEMBLY A1M1 CIRCUIT



MULTIPLIER SWITCH ASSEMBLY A1 CIRCUIT



D02470-6007-1

NOTES: 1. UNLESS OTHERWISE SPECIFIED RESISTANCES ARE IN OHMS CAPACITANCES ARE IN MICROFARADS

2. HEAVY LINE INDICATES MAIN FORWARD TRANSFER PATH.

3. * R2 AND R39 ARE SELECTED IN TEST, NOMINALLY THEY ARE 0Ω

MULTIPLIER SWITCH ASSEMBLY A1, A1M1 & PREAMPLIFIER ASSEMBLY A2 SCHEMATICS

FIGURE 5.4

PARTS ON A3

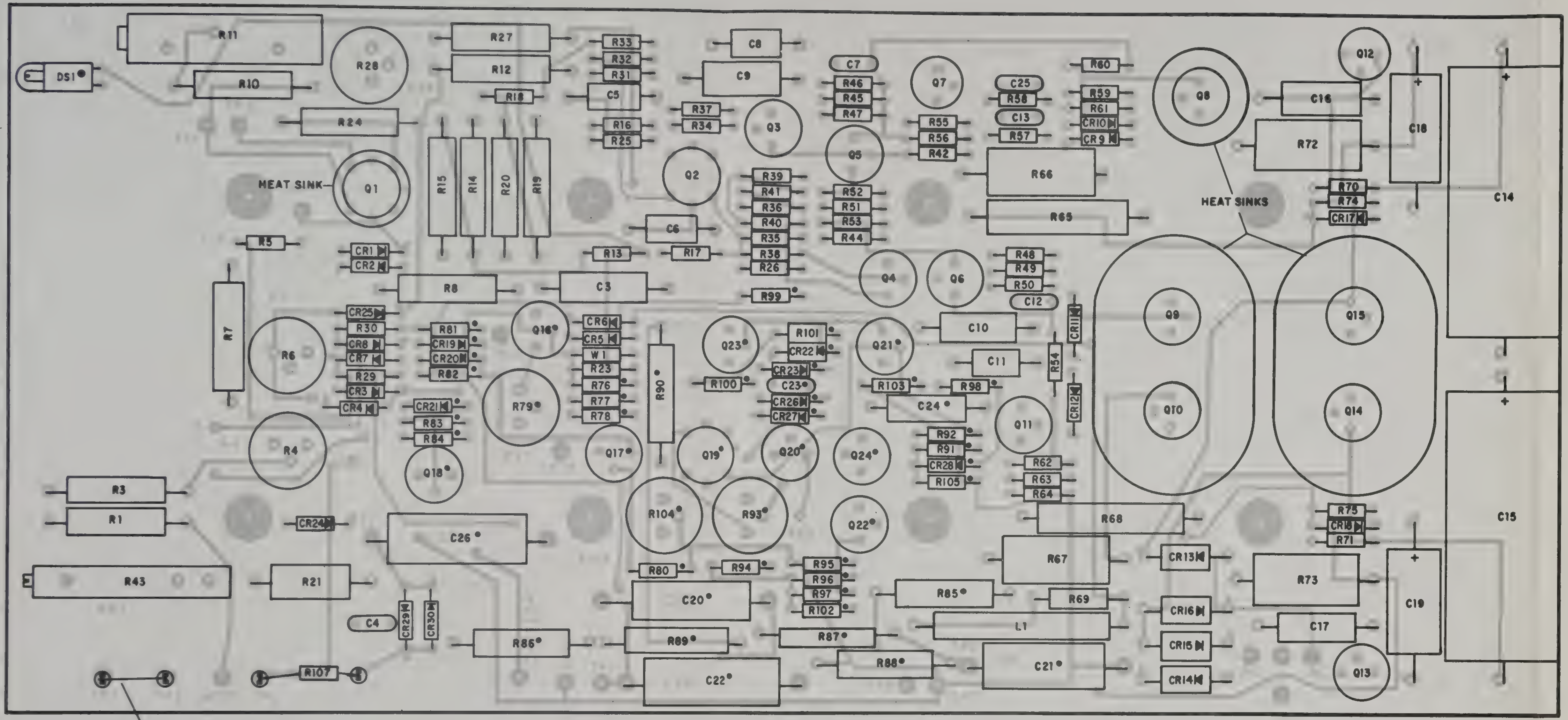
FIGURE 5.5

TABLE 5.3 A3 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
A3	**POST AMPLIFIER ASSEMBLY**	**02470-6001**	**04404**			
C3	C: fxd, my, 0.018 μf, 10%, 200v	0160-0302	56289	192P18392 (PTS)	1	1
C4	C: fxd, mica, 180 pf, 2%	0140-0219	04062	RDM15F181G3C	1	1
C5, 6	C: fxd, my, 0.0015 μf, 10%, 200v	0160-0298	56289	192P15292 (PTS)	2	1
C7, 12	C: fxd, mica, 560 pf, 2%	0140-0178	04062	RDM15F561G3C	2	1
C8, 11	C: fxd, my, 0.0027 μf, 10%, 200v	0160-0300	56289	192P27292 (PTS)	2	1
C9, 10, 16, 17	C: fxd, my, 0.01 μf, 10%, 200v	0160-0161	56289	192P10392 (PTS)	4	2
C13	C: fxd, mica, 270 pf, 5%, 500v	0140-0206	04062	DM15F271J	1	1
C14, 15	C: fxd, elect, 300 μf, -10%, +75%, 40v	0180-1805	56289	34D307G040GJ2	2	1
C18, 19	C: fxd, elect, Ta, 100 μf, 20%, 20v	0180-0098	56289	150D107X0020S2	2	1
C25	C: fxd, mica, 10 pf, 5%	0160-0205	04062	RDM15C100J5S	1	1
C26	C: fxd; value is selected from the following values to provide customer-specified bandwidth.					
	Bandwidth / C26 Value (10%)					
	DC - 50 KHz / C26 not installed	----------			---	---
	DC - 30 KHz / 270 pf	0140-0015	28480		*	*
	DC - 20 KHz / 560 pf	0140-0059	00853	RCM20E561J	*	*
	DC - 10 KHz / 0.0015 μf	0160-0298	56289	192P15292 (PTS)	*	*
	DC - 5 KHz / 0.0027 μf	0160-0300	56289	192P27292 (PTS)	*	*
	DC - 3 KHz / 0.0047 μf	0160-0157	56289	192P47292 (PTS)	*	*
	DC - 2 KHz / 0.0068 μf	0160-0159	56289	192P68292 (PTS)	*	*
	DC - 1 KHz / 0.015 μf	0160-0194	56289	192P15392	*	*
	DC - 500 Hz / 0.027 μf	0170-0066	56289	192P27392 (PTS)	*	*
	DC - 300 Hz / 0.047 μf	0170-0040	56289	192P47392A(PTS)	*	*
	DC - 200 Hz / 0.068 μf	0160-0166	56289	192P68392 (PTS)	*	*
	DC - 100 Hz / 0.15 μf	0160-0303	56289	192P15492 (PTS)	*	*
	DC - 50 Hz / 0.27 μf		13934#	Type 7x	*	*
	DC - 30 Hz / 0.47 μf		13934#	Type 7x	*	*
	DC - 20 Hz / 0.68 μf		13934#	Type 7x	*	*
	DC - 10 Hz / 1.5 μf		13934#	Type 7x	*	*
CR1-4, 29, 30	Diode: si	1901-0156	03877	SG-3288	6	3
CR5, 6	Diode: si, avalanche, 10.5v, selected	1902-0570	28480		2	2
CR7, 8	Diode: avalanche, 6.2v	1902-0033	03877	1N823	2	2
CR9-12, 24	Diode: si	1901-0025	03877	SG-817	5	3
CR13-16	Diode: si	1901-0026	04713	SR-1358-8	4	3
CR17, 18	Diode: avalanche	1902-3224	04713	1N935	2	2
CR25	Diode: ge	1910-0016	93332	D2361	1	2
L1	Choke: 10 μh	9100-1734	76493	4622	1	1
Q1	Transistor, dual: si, NPN	1854-0208	28480		1	1
Q2	Transistor, dual: si, PNP	1853-0032	28480		1	1
Q3, 4, 7	Transistor: si, NPN	1854-0211	04713	2N2501	3	1
Q5, 6, 8	Transistor: si, PNP	1853-0008	04713	2N3250	3	1
Q9, 11, 15	Transistor: si, NPN	1854-0039	04713	2N3053	3	1
Q10, 14	Transistor: si, PNP	1853-0027	04713	SM4787	2	1
Q12	Transistor: si, NPN	1854-0003	07263	S-7088	1	1
Q13	Transistor: si, PNP	1853-0001	07263	S-3251	1	1

M0183

* Only one capacitor is supplied as C26; the QTY and 1-YR SPA are 1
\# 13934 identifies Midwec Corp., Oshkosh, Nebraska, not listed in Table 6-1 at the end of this handbook.



WIRE SHORT IS REPLACED IN 2470A-M3 WITH CONNECTIONS TO VERNIER CONTROL R106

● DETERMINED BY CUSTOMER ORDER, AS FOLLOWS:

C26 VALUE IS SELECTED TO PROVIDE REQUESTED BANDWIDTH OF MAIN OUTPUT.
DS1, CR19-21, Q16-18, AND R76-84 ARE ON 2470A-M4 (2470A WITH OVERLOAD INDICATOR)
C20-24, CR22, 23, 26-28, Q19-24, AND R85-105 ARE ON 2470A-M5
(2470A WITH SECOND, BUFFERED OUTPUT STAGE)

PARTS ON A3

FIGURE 5.5

TABLE 5.3 A3 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
A3	**POST AMPLIFIER ASSEMBLY**	**02470-6001**	**04404**			
C3	C: fxd, my, 0.018 µf, 10%, 200v	0160-0302	56289	192P18392 (PTS)	1	1
C4	C: fxd, mica, 180 pf, 2%	0140-0219	04062	RDM15F181G3C	1	1
C5, 6	C: fxd, my, 0.0015 µf, 10%, 200v	0160-0298	56289	192P15292 (PTS)	2	1
C7, 12	C: fxd, mica, 560 pf, 2%	0140-0178	04062	RDM15F561G3C	2	1
C8, 11	C: fxd, my, 0.0027 µf, 10%, 200v	0160-0300	56289	192P27292 (PTS)	2	1
C9, 10, 16, 17	C: fxd, my, 0.01 µf, 10%, 200v	0160-0161	56289	192P10392 (PTS)	4	2
C13	C: fxd, mica, 270 pf, 5%, 500v	0140-0206	04062	DM15F271J	1	1
C14, 15	C: fxd, elect, 300 µf, -10%, +75%, 40v	0180-1805	56289	34D307G040GJ2	2	1
C18, 19	C: fxd, elect, Ta, 100 µf, 20%, 20v	0180-0098	56289	150D107X0020S2	2	1
C25	C: fxd, mica, 10 pf, 5%	0160-0205	04062	RDM15C100J5S	1	1
C26	C: fxd; value is selected from the following values to provide customer-specified bandwidth.					
	Bandwidth — C26 Value (10%)					
	DC - 50 KHz — C26 not installed	----------			---	---
	DC - 30 KHz — 270 pf	0140-0015	28480		*	*
	DC - 20 KHz — 560 pf	0140-0059	00853	RCM20E561J	*	*
	DC - 10 KHz — 0.0015 µf	0160-0298	56289	192P15292 (PTS)	*	*
	DC - 5 KHz — 0.0027 µf	0160-0300	56289	192P27292 (PTS)	*	*
	DC - 3 KHz — 0.0047 µf	0160-0157	56289	192P47292 (PTS)	*	*
	DC - 2 KHz — 0.0068 µf	0160-0159	56289	192P68292 (PTS)	*	*
	DC - 1 KHz — 0.015 µf	0160-0194	56289	192P15392	*	*
	DC - 500 Hz — 0.027 µf	0170-0066	56289	192P27392 (PTS)	*	*
	DC - 300 Hz — 0.047 µf	0170-0040	56289	192P47392A(PTS)	*	*
	DC - 200 Hz — 0.068 µf	0160-0166	56289	192P68392 (PTS)	*	*
	DC - 100 Hz — 0.15 µf	0160-0303	56289	192P15492 (PTS)	*	*
	DC - 50 Hz — 0.27 µf		13934#	Type 7x	*	*
	DC - 30 Hz — 0.47 µf		13934#	Type 7x	*	*
	DC - 20 Hz — 0.68 µf		13934#	Type 7x	*	*
	DC - 10 Hz — 1.5 µf		13934#	Type 7x	*	*
CR1-4, 29, 30	Diode: si	1901-0156	03877	SG-3288	6	3
CR5, 6	Diode: si, avalanche, 10.5v, selected	1902-0570	28480		2	2
CR7, 8	Diode: avalanche, 6.2v	1902-0033	03877	1N823	2	2
CR9-12, 24	Diode: si	1901-0025	03877	SG-817	5	3
CR13-16	Diode: si	1901-0026	04713	SR-1358-8	4	3
CR17, 18	Diode: avalanche	1902-3224	04713	1N935	2	2
CR25	Diode: ge	1910-0016	93332	D2361	1	2
L1	Choke: 10 µh	9100-1734	76493	4622	1	1
Q1	Transistor, dual: si, NPN	1854-0208	28480		1	1
Q2	Transistor, dual: si, PNP	1853-0032	28480		1	1
Q3, 4, 7	Transistor: si, NPN	1854-0211	04713	2N2501	3	1
Q5, 6, 8	Transistor: si, PNP	1853-0008	04713	2N3250	3	1
Q9, 11, 15	Transistor: si, NPN	1854-0039	04713	2N3053	3	1
Q10, 14	Transistor: si, PNP	1853-0027	04713	SM4787	2	1
Q12	Transistor: si, NPN	1854-0003	07263	S-7088	1	1
Q13	Transistor: si, PNP	1853-0001	07263	S-3251	1	1

M0183

* Only one capacitor is supplied as C26; the QTY and 1-YR SPA are 1

13934 identifies Midwec Corp., Oshkosh, Nebraska, not listed in Table 6-1 at the end of this handbook.

TABLE 5.3 (Cont'd)

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	POST AMPLIFIER ASSEMBLY A3 (Cont'd)					
R1	R: fxd, cflm, 100 ohms, 1%, 1/2w	0727-0864	28480		1	1
R3, 7	R: fxd, cflm, 1 Meg, 1%, 1/2w	0727-0274	28480		2	1
R4, 6, 28	R: var, ww, 10K, 5%, 1w	2100-0363	75042	CT-100 (OBD)	3	1
R5	R: fxd, mtflm, 56K, 2%, 1/8w	0757-0966	28480		1	1
R8	R: fxd, cflm, 10K, 1%, 1/2w	0727-0891	28480		1	1
R10, 12, 24, 27	R: fxd, mtflm, 383K, 1%, 1/2w	0757-0133	28480		4	2
R11	R: var, ww, 10K, 10%, 1w, 20 turns	2100-0451	28480		1	1
R13	R: fxd, mtflm, 82K, 2%, 1/8w	0757-0970	28480		1	1
R14, 15	R: fxd, mtflm, 511 ohms, 1%, 1/2w	0698-4309	28480		2	1
R16, 17	R: fxd, mtflm, 62K, 2%, 1/8w	0757-0967	28480		2	1
R18	R: fxd, mtflm, 51K, 2%, 1/8w	0757-0965	28480		1	1
R19, 20	R: fxd, mtflm, 51.1K, 1%, 1/2w	0698-4320	28480		2	1
R21	R: fxd, ww, 9.9K, 0.05%, 1/16w, 5ppm/° C	0811-1700	07088	KB130 (OBD)	1	1
R23, 63	R: fxd, mtflm, 1K, 2%, 1/8w	0757-0924	28480		2	1
R25, 26, 55	R: fxd, mtflm, 560 ohms, 2%, 1/8w	0757-0918	28480		3	1
R29, 30	R: fxd, mtflm, 1.6K, 2%, 1/8w	0757-0929	28480		2	1
R31, 32, 37, 38, 56, 61	R: fxd, mtflm, 100 ohms, 2%, 1/8w	0757-0900	28480		6	2
R33	R: fxd, mtflm, 15K, 2%, 1/8w	0757-0952	28480		1	1
R34, 35	R: fxd, mtflm, 22K, 2%, 1/8w	0757-0956	28480		2	1
R36, 64	R: fxd, mtflm, 6.2K, 2%, 1/8w	0757-0943	28480		2	1
R39, 40	R: fxd, mtflm, 300 ohms, 2%, 1/8w	0757-0911	28480		2	1
R41	R: fxd, mtflm, 8.2K, 2%, 1/8w	0757-0946	28480		1	1
R42, 44	R: fxd, mtflm, 11K, 2%, 1/8w	0757-0949	28480		2	1
R43	R: var, ww, 200 ohms, 10%, 20 turns (GAIN)	2100-1655	09145	170P (OBD)	1	1
R45, 50	R: fxd, mtflm, 1.8K, 2%, 1/8w	0757-0930	28480		2	1
R46, 49	R: fxd, mtflm, 6.8K, 2%, 1/8w	0757-0944	28480		2	1
R47, 48	R: fxd, mtflm, 30K, 2%, 1/8w	0757-0959	28480		2	1
R51, 59	R: fxd, mtflm, 2.7K, 2%, 1/8w	0757-0934	28480		2	1
R52, 53, 107	R: fxd, mtflm, 56 ohms, 2%, 1/8w	0757-0894	28480		3	1
R54, 57, 60	R: fxd, mtflm, 10K, 2%, 1/8w	0757-0948	28480		3	1
R58	R: fxd, mtflm, 3K, 2%, 1/8w	0757-0935	28480		1	1
R62	R: fxd, mtflm, 200 ohms, 2%, 1/8w	0757-0907	28480		1	1
R65, 68	R: fxd, ww, 20 ohms, 5%, 3w	0811-1692	28480		2	1
R66, 67, 72, 73	R: fxd, comp, 12 ohms, 5%, 2w	0692-1205	01121	HB1205	4	2
R69	R: fxd, comp, 10 ohms, 5%, 1/2w	0686-1005	01121	EB1005	1	1
R70, 71	R: fxd, mtflm, 1.2K, 2%, 1/8w	0757-0926	28480		2	1
R74, 75	R: fxd, mtflm, 3.3K, 2%, 1/8w	0757-0936	28480		2	1
W1, W2**	Jumper: insulated	8159-0005	82142	OBD	2	1

M0183

** W2 is replaced by VERNIER R106 in 2470A-M3

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
A3M4	**POST AMPLIFIER ASSEMBLY** (replaces A3 in 2470A-M4 instruments)	**02470-6004**	**04404**			
	Add the following components to Post Amplifier Assembly A3 (02470-6001)					
CR19-21	Diode: si	1901-0025	03877	SG-817	3	2
DS1	Lamp: incandescent, O/L indicator	2140-0090	28480		1	3
Q16, 17	Transistor: si, PNP	1853-0008	28480		2	1
Q18	Transistor: si, PNP	1853-0007	28480		1	1
R76, 77	R: fxd, comp, 1 Meg, 5%, 1/4w	0683-1055	01121	CB1055	2	1
R78	R: fxd, mtflm, 3.9K, 2%, 1/8w	0757-0938	28480		1	1
R79	R: var, ww, 100 ohms, 5%, 1w	2100-1450	75042	CT-100 (OBD)	1	1
R80	R: fxd, mtflm, 1K, 2%, 1/8w	0757-0924	28480		1	1
R81, 82	R: fxd, mtflm, 8.2K, 2%, 1/8w	0757-0946	28480		2	1
R83	R: fxd, mtflm, 22K, 2%, 1/8w	0757-0956	28480		1	1
R84	R: fxd, mtflm, 560 ohms, 2%, 1/8w	0757-0918			1	1
A3M5	**POST AMPLIFIER ASSEMBLY** (replaces A3 in 2470A-M5 instruments)	**02470-6005**	**04404**			
	Add the following components to Post Amplifier Assembly A3 (02470-6001):					
C20	C: fxd; value is selected from the following values to provide customer-specified bandwidth for second output.					
	Bandwidth — C20 Value (10%)					
	DC - 50 KHz — 0.0018 uf	0160-0299	56289	192P18292 (PTS)	*	*
	DC - 30 KHz — 0.0033 uf	0160-0155	56289	192P33292 (PTS)	*	*
	DC - 20 KHz — 0.0047 uf	0160-0157	56289	192P47292 (PTS)	*	*
	DC - 10 KHz — 0.01 uf	0160-0161	56289	192P10392 (PTS)	*	*
	DC - 5 KHz — 0.018 uf	0160-0302	56289	192P18392 (PTS)	*	*
	DC - 3 KHz — 0.033 uf	0160-0163	56289	192P33392 (PTS)	*	*
	DC - 2 KHz — 0.047 uf	0170-0040	56289	192P47392A(PTS)	*	*
	DC - 1 KHz — 0.1 uf	0160-0168	56289	192P10492 (PTS)	*	*
	DC - 500 Hz — 0.15 uf	0160-0303	56289	192P15492 (PTS)	*	*
	DC - 300 Hz — 0.33 uf		13934#	Type 7x	*	*
	DC - 200 Hz — 0.47 uf		13934#	Type 7x	*	*
	DC - 100 Hz — 1 uf		13934#	Type 7x	*	*
	DC - 50 Hz — 1.8 uf		13934#	Type 7x	*	*
	DC - 30 Hz — 3.3 uf		13934#	Type 7x	*	*
	DC - 20 Hz — 4.7 uf		13934#	Type 7x	*	*
	DC - 10 Hz — 10 uf		13934#	Type 7x	*	*
C21, 22	C: fxd; value is selected from the following values to provide customer-specified bandwidth for second output.					
	Bandwidth — C21, 22 Value (10%)					
	DC - 50 KHz — 0.001 uf	0160-0153	56289	192P10292 (PTS)	*	*
	DC - 30 KHz — 0.0015 uf	0160-0298	56289	192P15292 (PTS)	*	*
	DC - 20 KHz — 0.0027 uf	0160-0300	56289	192P27292 (PTS)	*	*
	DC - 10 KHz — 0.0047 uf	0160-0157	56289	192P47292 (PTS)	*	*

M0183

* Only one capacitor is supplied as C20, C21, or C22; the QTY and 1-YR SPA are 1 for C20 and the QTY is 2 and the 1-YR SPA is 1 for C21, 22

\# 13934 identifies Midwec Corp., Oshkosh, Nebraska, not listed in Table 6-1 at the end of this handbook.

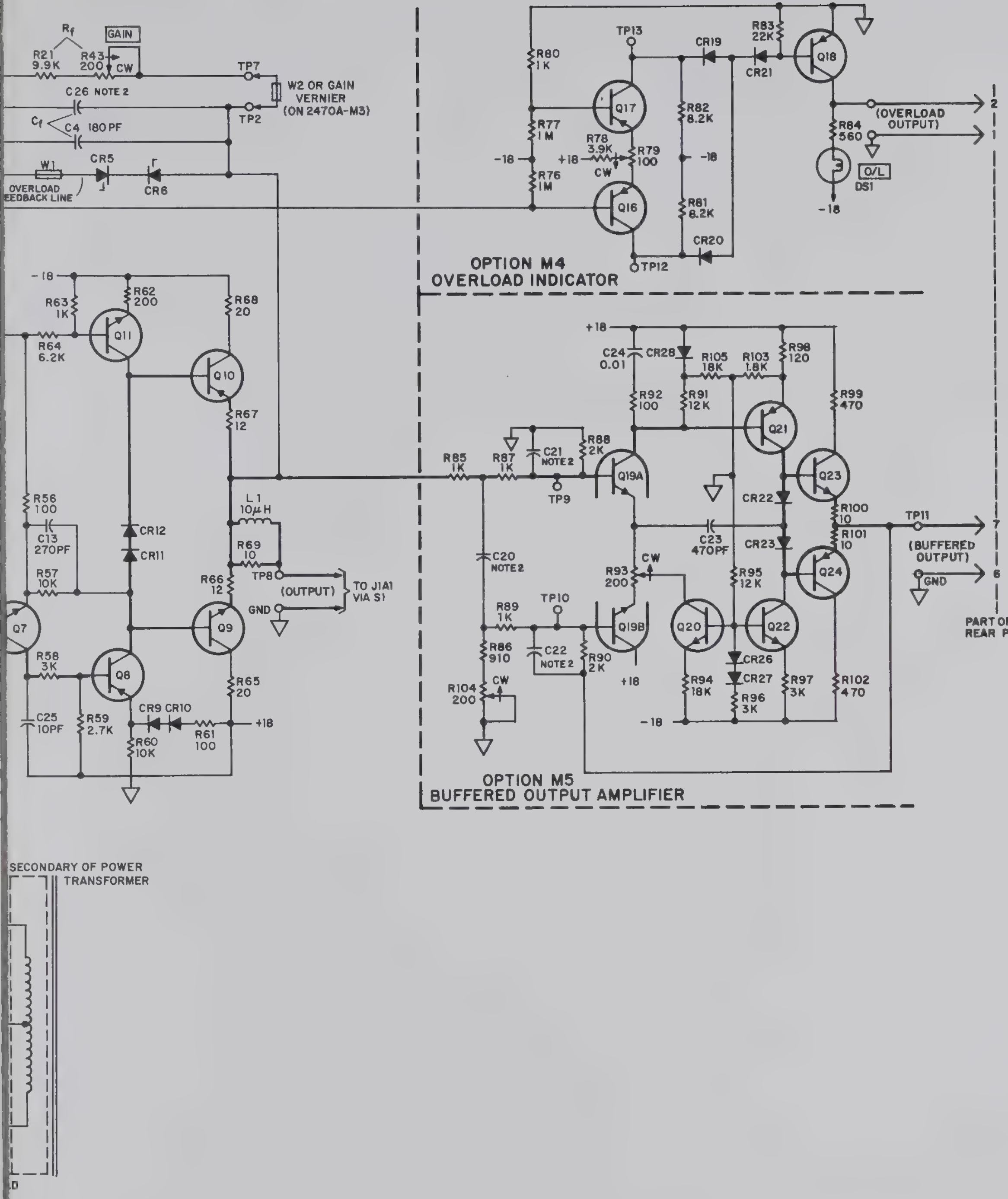
TABLE 5.3 (Cont'd)

CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	POST AMPLIFIER ASSEMBLY A3M5 (Cont'd)					
Continued -	Bandwidth — C21, 22 Value (10%)					
	DC - 5 KHz — 0.01 μf	0160-0161	28480		*	*
	DC - 3 KHz — 0.015 μf	0160-0194	28480		*	*
	DC - 2 KHz — 0.027 μf	0170-0066	28480		*	*
	DC - 1 KHz — 0.047 μf	0170-0040	28480		*	*
	DC - 500 Hz — 0.1 μf	0160-0168	28480		*	*
	DC - 300 Hz — 0.15 μf	0160-0303	28480		*	*
	DC - 200 Hz — 0.27 μf		13934#	Type 7X	*	*
	DC - 100 Hz — 0.47 μf		13934#	Type 7X	*	*
	DC - 50 Hz — 1 μf		13934#	Type 7X	*	*
	DC - 30 Hz — 1.6 μf		13934#	Type 7X	*	*
	DC - 20 Hz — 2.7 μf		13934#	Type 7X	*	*
	DC - 10 Hz — 4.7 μf		13934#	Type 7X	*	*
C23	C: fxd, mica, 470 pf, 5%, 300v	0160-2210	28480		1	1
C24	C: fxd, my, 0.01 μf, 10%, 200v	0160-0161	28480		1	1
CR22, 23 26-28	Diode: Si, 100v	1901-0025	28480		5	3
Q19	Transistor: dual: Si, NPN	1854-0207	28480		1	1
Q20	Transistor: Si, NPN	1854-0209	01295	2N910	1	1
Q21	Transistor: Si, PNP	1853-0007	04713	2N3251	1	1
Q22, 23	Transistor: Si, NPN	1854-0212	02735	2N2897	2	1
Q24	Transistor: Si, PNP	1853-0008	04713	2N3250	1	1
R85, 87, 89	R: fxd, mtflm, 1K, 1%, 1/2 w	0757-0021	28480		3	1
R86	R: fxd, mtflm, 910 ohms, 1%, 1/2 w	0757-0211	28480		1	1
R88, 90	R: fxd, mtflm, 2K, 1%, 1/2 w	0698-4313	28480		2	1
R91, 95	R: fxd, mtflm, 12K, 2%, 1/8 w	0757-0950	28480		2	1
R92	R: fxd, mtflm, 100 ohms, 2%, 1/8 w	0757-0900	28480		1	1
R93, 104	R: var, ww, 200 ohms, 5%, 1 w	2100-0737	28480		2	1
R94, 105	R: fxd, mtflm, 18K, 2%, 1/8 w	0757-0954	28480		2	1
R96, 97	R: fxd, mtflm, 3K, 2%, 1/8 w	0757-0935	28480		2	1
R98	R: fxd, mtflm, 120 ohms, 2%, 1/8 w	0757-0902	28480		1	1
R99, 102	R: fxd, mtflm, 470 ohms, 2%, 1/8 w	0757-0916	28480		2	1
R100, 101	R: fxd, comp, 10 ohms, 5%, 1/4 w	0683-1005	28480		2	1
R103	R: fxd, mtflm, 1.8K, 2%, 1/8 w	0757-0930	28480		1	1
A3M4/M5	**POST AMPLIFIER ASSEMBLY** (replaces A3 in 2470A-M4/M5 instruments) This assembly contains all components listed for 02470-6001 and all components used to make up 02470-6004 and 02470-6005					

M0183

* Only one capacitor is supplied as C20, C21, or C22; the QTY and 1-YR SPA are 1 for C20 and the QTY is 2 and the 1-YR SPA is 1 for C21, 22

\# 13934 identifies Midwec Corp., Oshkosh, Nebraska, not listed in Table 6-1 at the end of this handbook.



POST AMPLIFIER ASSEMBLY

A3 SCHEMATIC

FIGURE 5.6

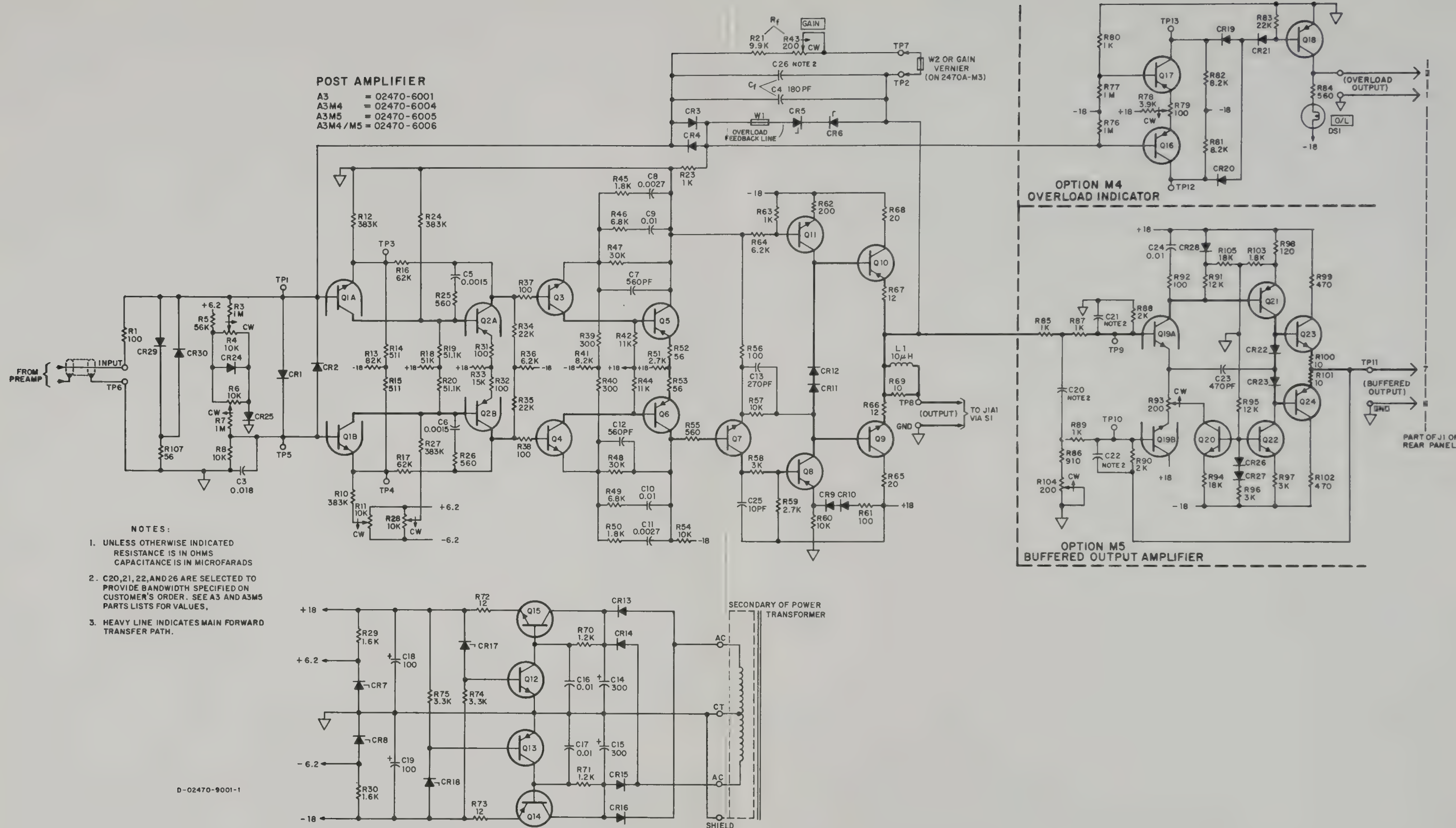
TABLE 5.3 (Cont'd)

CIRCUIT REFERENCE	DESCRIPTION	hp STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	POST AMPLIFIER ASSEMBLY A3M5 (Cont'd)					
Continued -	Bandwidth — C21, 22 Value (10%)					
	DC - 5 KHz — 0.01 µf	0160-0161	28480		*	*
	DC - 3 KHz — 0.015 µf	0160-0194	28480		*	*
	DC - 2 KHz — 0.027 µf	0170-0066	28480		*	*
	DC - 1 KHz — 0.047 µf	0170-0040	28480		*	*
	DC - 500 Hz — 0.1 µf	0160-0168	28480		*	*
	DC - 300 Hz — 0.15 µf	0160-0303	28480		*	*
	DC - 200 Hz — 0.27 µf		13934#	Type 7×	*	*
	DC - 100 Hz — 0.47 µf		13934#	Type 7×	*	*
	DC - 50 Hz — 1 µf		13934#	Type 7×	*	*
	DC - 30 Hz — 1.6 µf		13934#	Type 7×	*	*
	DC - 20 Hz — 2.7 µf		13934#	Type 7×	*	*
	DC - 10 Hz — 4.7 µf		13934#	Type 7×	*	*
C23	C: fxd, mica, 470 pf, 5%, 300v	0160-2210	28480		1	1
C24	C: fxd, my, 0.01 µf, 10%, 200v	0160-0161	28480		1	1
CR22, 23 26-28	Diode: Si, 100v	1901-0025	28480		5	3
Q19	Transistor: dual: Si, NPN	1854-0207	28480		1	1
Q20	Transistor: Si, NPN	1854-0209	01295	2N910	1	1
Q21	Transistor: Si, PNP	1853-0007	04713	2N3251	1	1
Q22, 23	Transistor: Si, NPN	1854-0212	02735	2N2897	2	1
Q24	Transistor: Si, PNP	1853-0008	04713	2N3250	1	1
R85, 87, 89	R: fxd, mtflm, 1K, 1%, 1/2 w	0757-0021	28480		3	1
R86	R: fxd, mtflm, 910 ohms, 1%, 1/2 w	0757-0211	28480		1	1
R88, 90	R: fxd, mtflm, 2K, 1%, 1/2 w	0698-4313	28480		2	1
R91, 95	R: fxd, mtflm, 12K, 2%, 1/8 w	0757-0950	28480		2	1
R92	R: fxd, mtflm, 100 ohms, 2%, 1/8 w	0757-0900	28480		1	1
R93, 104	R: var, ww, 200 ohms, 5%, 1 w	2100-0737	28480		2	1
R94, 105	R: fxd, mtflm, 18K, 2%, 1/8 w	0757-0954	28480		2	1
R96, 97	R: fxd, mtflm, 3K, 2%, 1/8 w	0757-0935	28480		2	1
R98	R: fxd, mtflm, 120 ohms, 2%, 1/8 w	0757-0902	28480		1	1
R99, 102	R: fxd, mtflm, 470 ohms, 2%, 1/8 w	0757-0916	28480		2	1
R100, 101	R: fxd, comp, 10 ohms, 5%, 1/4 w	0683-1005	28480		2	1
R103	R: fxd, mtflm, 1.8K, 2%, 1/8 w	0757-0930	28480		1	1
A3M4/M5	**POST AMPLIFIER ASSEMBLY** (replaces A3 in 2470A-M4/M5 instruments) This assembly contains all components listed for 02470-6001 and all components used to make up 02470-6004 and 02470-6005					

M0183

* Only one capacitor is supplied as C20, C21, or C22; the QTY and 1-YR SPA are 1 for C20 and the QTY is 2 and the 1-YR SPA is 1 for C21, 22

\# 13934 identifies Midwec Corp., Oshkosh, Nebraska, not listed in Table 6-1 at the end of this handbook.



NOTES:

1. UNLESS OTHERWISE INDICATED RESISTANCE IS IN OHMS CAPACITANCE IS IN MICROFARADS
2. C20,21,22,AND 26 ARE SELECTED TO PROVIDE BANDWIDTH SPECIFIED ON CUSTOMER'S ORDER. SEE A3 AND A3M5 PARTS LISTS FOR VALUES.
3. HEAVY LINE INDICATES MAIN FORWARD TRANSFER PATH.

POST AMPLIFIER ASSEMBLY

A3 SCHEMATIC

FIGURE 5.6

APPENDIX 5.1
CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co	Redwood City, Calif.
04811	Precision Coil Spring Co	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc	Wakefield, Mass.
06004	Bassick Co., The	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Semcor Div. Components Inc	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp	Culver City, Calif.
07263	Fairchild Camera & Inst Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.

Code No	Manufacturer	Address
08145	U.S. Engineering Co	Los Angeles, Calif.
08289	Blinn, Delbert Co	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dubilier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	So. Pasadena, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Amelco Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Mi.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Inc.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	Bendix Corp., The Eclipse-Poineer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.

Code No.	Manufacturer	Address
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Revere Wollansak Div. Minn. Mining & Mfg. Co.	St. Paul, Minn
70276	Allen Mfg. Co.	Hartford, Conn.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema Plant, Hi-Q Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast Co., Div. Victoreen Instr. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.

Code No.	Manufacturer	Address
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., The Bendix Pacific Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80130	Times Telephoto Equipment	New York, N.Y.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Labe. Corp.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . .
81483	International Rectifier Corp.	El Segundo, Calif
81541	Airpax Electronics, Inc.	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Defense Prod. Division	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co	Joliet, Ill.
82866	Research Products Corp	Madison, Wis.
82877	Rotron Mfg. Co., Inc	Woodstock, N.Y.
82893	Vector Electronic Co	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div	Ogallala, Neb
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.

From. FSC. Handbook Supplements
H4-1 Dated JULY 1965
H4-2 Dated NOV 1962

APPENDIX 5.1
CODE LIST OF MANUFACTURERS
(Continued)

Code No.	Manufacturer	Address
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp & Devices Div.	Harrison, N.J.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88421	Federal Telephone & Radio Corp.	Clifton, N.J.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89665	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.

Code No.	Manufacturer	Address
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92196	Universal Industries, Inc.	City of Industry, Calif.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Memcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.

Code No.	Manufacturer	Address
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind. Elect. Products Div.	San Marino, Calif.

Code No.	Manufacturer	Address
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK

0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

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H4-2 Dated NOV 1962

UPDATING SUPPLEMENT

for

Manual Stock No. 02470-9022

Published 4/67

for

MODEL 2470A

DATA AMPLIFIER

INTRODUCTION

This supplement contains information for updating the manual to cover HP 2470A Data Amplifiers with serial number prefixes later than 644-.

To adapt this manual to instruments with serial prefixes later than 644-, make changes as follows:

Instrument Serial Prefix	Applicable Change No(s).
714-	1

CHANGE 1 (applies to 2470A with serial number prefix 714- or later)

Page 1-4, Table 1.1: Under ZERO DRIFT (OFFSET), delete the footnote:

Add $10\mu v$ to rti zero drift figures for operation in free air (without forced air ventilation through the 2470A from rear to front at 1 cfm, minimum).

Page 2-1, change paragraph 2.1.1 to read:

The 2470A is self-cooled by convection when operated in free air. It is ready to operate immediately after turn-on, but meets its zero drift specifications only after 1-1/2 hour warmup in free air. Forced air ventilation provided by the Combining Case reduces required warmup time to 30 minutes, provided that all unoccupied spaces in the case are covered by blank filler panels and the air filter at the rear of the case is cleaned regularly, as specified on page 6 of the instruction booklet supplied with the Combining Case.

Page 2-14, change item 1 of paragraph 2.6.1 to read:

1. Zero drift (offset): $\pm 5\mu v$ rti $\pm 50\mu v$ rto for 8 hours.
   $\pm 1\mu v$ ± 0.5 namp rti $\pm 10\mu v$ rto per $^{\circ}C$ change of ambient temperature.

CHANGE 1 (Cont'd.)

Page 2-14, change the fifth line of paragraph 2.6.2 to read:

following formula.

Page 2-15, change third line of heading for Table 2.1 to read:

(assuming constant temperature after calibration)

Page 4-4, delete NOTE C.

Page 3 of 5 of Performance Check Test Card, check 7, steps 4 and 8, from Specification Limits column, delete:

(±.2 mv in free air)

Page 5 of 5 of Performance Check Test Card, from the Specification Limits column, for the following checks and steps make corresponding deletions:

Check	Step	Delete
8	4	(< ±15.1 mv in free air)
8	5	(< ±1.55 mv in free air)
8	6	(< ±.2 mv in free air)
8	7	(< ±.28 mv in free air)
11	10 ‡	* < ±35.3 mv in free air

‡ deletion referenced is actually below step 10

Page 4-17, paragraph 4.3, change second and fifth paragraphs to read:

For access to test points and components on the Preamplifier circuit board, remove the three cover shield attaching screws and lift off the cover shield. Remove the isothermal cover for access to Q1, Q2, and Q3 and related parts.

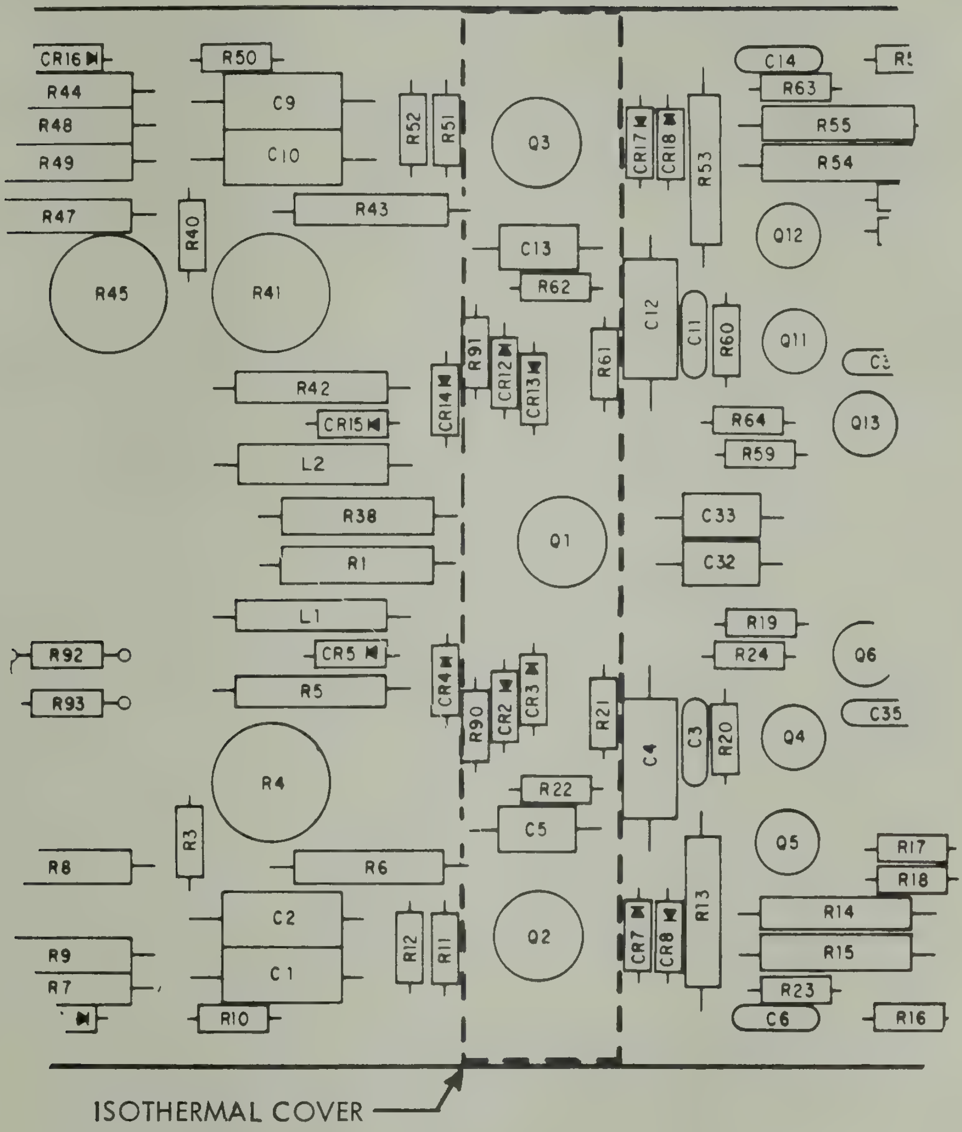
Reassembly of the 2470A after all internal maintenance has been accomplished is essentially the reverse of the procedure used to gain access. Slide the front or rear panel down into place on the dowel rods that are integral with the case. Line up the printed circuit board with the holes molded in the case, and snap in the plastic fasteners. Re-install the isolthermal cover on the Preamplifier board, placing it as indicated in Figure 5.3, page 5-6. Replace the Preamplifier cover shield and secure it with the attaching screws; be sure to install the nylon screw in the rear-most hole as marked on the cover shield. Close the case and secure the cross-straps.

Page 5-4, Table 5.1: To standard 2212A list, add:

Cover, Isothermal	5000-5709	04404	1

Page 5-6, Figure 5.3, add Isothermal Cover outline as indicated on page UD-3.

CHANGE 1 (Cont'd.)



LOCATION OF ISOTHERMAL COVER ON PREAMPLIFIER

BACKDATING SUPPLEMENT

for

Manual Stock No. 02470-9022

Published 4/67

for

MODEL 2470A

DATA AMPLIFIER

INTRODUCTION

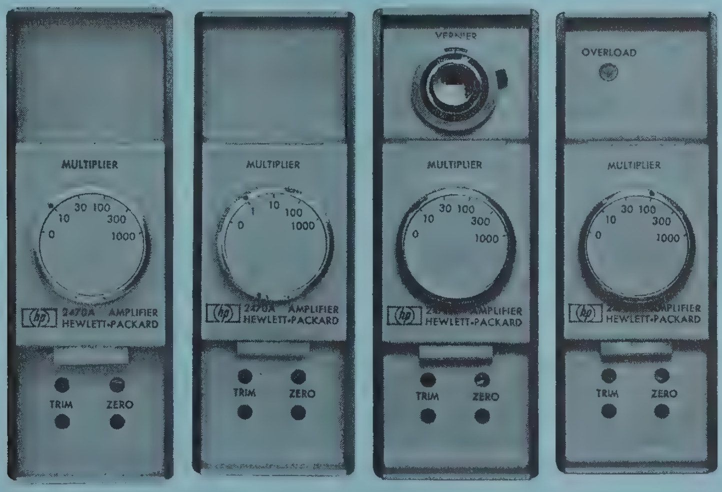
This supplement contains information for backdating the manual to cover HP-2470A Data Amplifiers with serial number prefixes earlier than 644-.

To adapt this manual to instruments with serial prefixes earlier than 644-, make changes as follows:

Instrument Serial Prefix	Applicable Change No(s).
640-	1
633-	1, 2
628-	1, 2, 3
552-	1, 2, 3, 4

CHANGE 1:

Illustrations showing front panels throughout the manual should be as shown below on 2470A Data Amplifiers with serial number prefixes 640- and earlier.



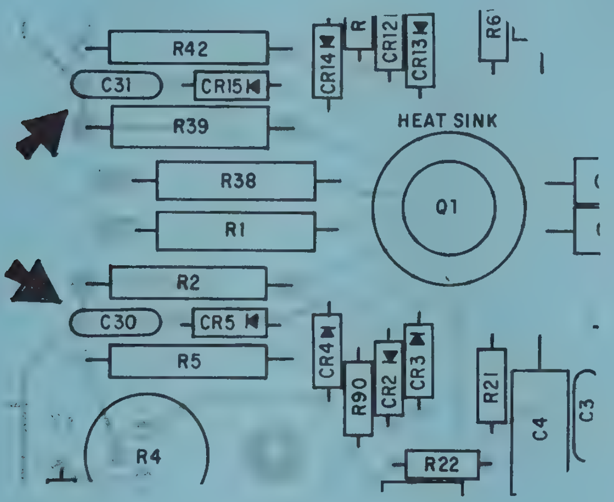
STD 2470A   2470A-M1   2470A-M3   2470A-M4

Add this sentence following paragraph 2.1.6:

The 2470A is removed from the Combining Case by squeezing up on the bar beneath the MULTIPLIER switch (to release the detent) and pulling the instrument out of the case.

CHANGE 2:

Figures 5.3 and 5.4: add C30 and C31 as indicated in the partial diagrams presented below.



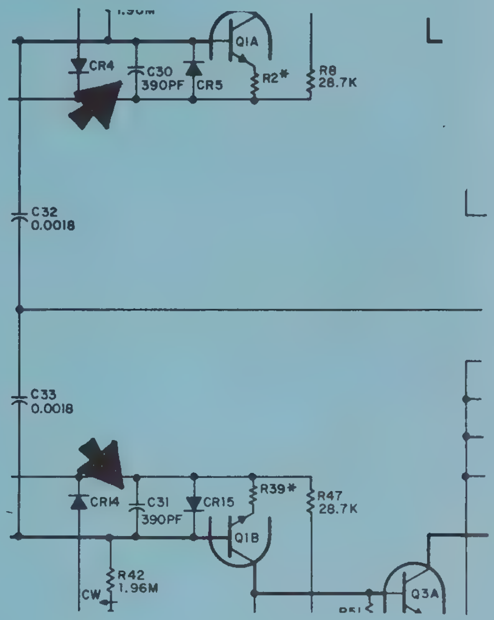


Table 5.2: Add the following entry:

				Qty
C30, 31	C: fxd, mica, 390 pf, 5%, 300v	0140-0200	04062	2

Figure 5.4, Table 5.2: change the following:

C8, 16 from 680 pf to 330 pf, HP Part No. from 0140-0208 to 0140-0207.

R11, 51 from 2.7K to 1.3K, HP Part No. from 0757-0934 to 0757-0927.

CHANGE 3:

Figure 5.1, Table 5.1: delete Thermal Cutout Switch S4 and connect line from F1 directly to center contact of POWER switch.

CHANGE 4:

Figures 5.2 and 5.3, Table 5.2:

Delete L1 and L2; in Figure 5.2 designate L1 and L2, R2 and R39 respectively.

Figure 5.3, Table 5.2:

C22, 23, 28, and 29 may be 40 μf or 47 μf in your instrument; nevertheless, when replacing any of these capacitors, use the 75 μf unit listed in the basic manual.

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